Engineering
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"ENGINEER," APRIL 29, 1927

With METALLURGICAL SUPPLEMENT.

The Engineer.

Established 1856.

Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 33, NORFOLK ST., STRAND, LONDON, W.C. 2.

VOL. CXLIII.—No. 3720] LONDON: FRIDAY EVENING, APRIL 29, 1927 [PRICE { WITH SUPPLEMENT } ONE SHILLING BY INLAND POST 1s. 8d.

PUBLIC NOTICES

The Director-General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for :—
1. 98,550 PAIRS BONDING FISH-PLATES.
2. 266 TONS CHAIR BOLTS.
3. About 545 TONS DISTANCE PIECES and KEYS for STEEL SLEEPERS.
Tenders due on the 10th May, 1927, for Nos. 1 and 2, and on the 13th May, 1927, for No. 3.
Specifications and forms of Tender obtainable from the above at a fee of 5s. per set, which will not be returned. 5362

Assistant Engineer REQUIRED by the GOVERNMENT of PALESTINE for the PUBLIC WORKS DEPARTMENT for 3 years' service, with possible permanency. Salary £400, rising to £550 a year by annual increments of £10, plus expatriation allowance of £50 a year and a temporary cost-of-living allowance of £44 10s. a year. Free passages. Candidates, single, 25 to 35 years of age, should have been trained in a Municipal Engineer's office and have had outside experience on the construction of roads and buildings and be competent to take direct charge of such works without trained assistance. Candidates who are A.M.I.C.E. will be given preference.—Apply at once by letter, stating age, experience, and qualifications, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, mentioning this paper and quoting M/15317. 5311

Assistant Engineers (10) REQUIRED for the PUBLIC WORKS DEPARTMENT of the FEDERATED MALAY STATES for four years' service, after which, subject to satisfactory service, the officers appointed will be eligible for confirmation in the permanent and pensionable establishment. It is probable that the number of permanent appointments will be sufficient for those officers whose services have been entirely satisfactory, but no absolute guarantee can be given. If at the end of four years' service an officer's services have been entirely satisfactory and he is not offered or declines further employment, he will be paid a bonus of 2850 dollars. Salary 400 dollars a month, rising to 800 dollars by annual increments of 25 dollars, plus a temporary non-pensionable allowance of 10 per cent. for bachelors and 20 per cent. for married men. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is considerably less than that of 2s. 4d. in the United Kingdom. No income tax at present imposed by the Federated Malay States Government. Free passages provided. Candidates, age 23 to 26, preferably unmarried, must have received a good theoretical training, preferably at a University or College, recognised by the Institution of Civil Engineers, and possess a Civil Engineering Degree or obtained such other diplomas or distinction in engineering as the Secretary of State may decide in any particular case or have completed articles with a civil engineer of good standing and have passed the examination for Associate Membership of the Institution of Civil Engineers. In addition, candidates must have had at least one year's practical experience of civil engineering under a qualified engineer.—Apply at once by letter, giving brief details of qualifications and experience and stating age, and whether married or single, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W. 1, quoting clearly at the head of application M/15224 5351

Civil Engineers (2) REQUIRED for the PUBLIC WORKS DEPARTMENT of TANGANYIKA TERRITORY for a tour of 20 to 30 months' service, with possible extension. Salary £480, rising by annual increments to £720 a year (with efficiency bar at £600). Outfit allowance of £30 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, aged 25 to 35, preferably unmarried, must have been regularly trained as civil engineers and be corporate members of the Institution of Civil Engineers. Must be capable of levelling, surveying, measuring up work and preparing designs of bridges, &c. Must have had at least three years' experience under a qualified civil engineer on the construction of Harbour Works, Drainage Works, Water Supply or other Public Works.—Apply at once by letter, stating age, qualifications, and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, mentioning this paper and quoting M/14402. 5352

Northampton Polytechnic INSTITUTE,
ST. JOHN-STREET, LONDON, E.C. 1.
A LABORATORY MECHANIC is REQUIRED for the Maintenance of Experimental and Workshop Plant in the Mechanical Engineering Laboratories. Applicants must have good all-round engineering experience and training, and should not be over 45. Applications, which should be in writing and which should state wages required, should be sent to the undersigned, from whom necessary forms of application may be obtained.
S. C. LAWS, M.A., M.Sc., Principal. 5339

The Institution of Structural ENGINEERS.
MODIFIED EXAMINATION FOR ASSOCIATE-MEMBERSHIP.
The next MODIFIED EXAMINATION for ASSOCIATE-MEMBERSHIP will be held on 21st MAY, and entries must be received by the 16th May. The Examination is for candidates having ten years' professional experience, and entries are subject to approval by the Board of Examiners. It should be noted that this Examination is liable to be permanently and finally closed by the Council at any time. It is intended only for those actually practising in the profession who have not the present time or opportunity to take the whole Examination. It is not intended for the ultimate use of present students, who should apply to sit for the ordinary Examinations.
Syllabus and full particulars from the undersigned.
MAURICE G. KIDDY, F.I.S.A., Secretary.
10, Upper Belgrave-street, London, S.W. 1. 5374

P2986.—APPLICANTS for this Position are THANKED and are informed that the POST has been FILLED. P2117 A

The Engineer

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PUBLIC NOTICES

Bombay, Baroda and Central INDIA RAILWAY COMPANY.
The Directors are prepared to receive up to Noon on Friday, 13th May, TENDERS for the SUPPLY of :—
1. WHEELS and AXLES for CARRIAGES and BRAKE VANS.
2. STEEL MATERIAL (PLATES, CHANNELS, ANGLES, FLATS, &c.).
Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG, Secretary.
Offices : 91, Petty France, Westminster, S.W. 1.
27th April, 1927. 5370

Administrative County of LONDON.
LEWISHAM BRANCH SEWER—BRANCH FROM HITHER GREEN
The London County Council invites TENDERS for the CONSTRUCTION in Tunnel, partly in compressed air, of about 3140 Lineal Feet of 5ft. internal diameter CAST IRON SEWER from Springbank-road to Thornford-road; the CONSTRUCTION of a TUMBLING BAY, SIX SIDE ENTRANCES and VENTILATORS, &c., all in the Metropolitan Borough of Lewisham.
Persons desiring to submit Tenders may obtain the form of Tender and contract, specification, bill of quantities and drawings on application to the Chief Engineer of the Council at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £10 by cheque or draft to the order of the London County Council. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application and the contract documents may be inspected before payment of the fee.
The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in the "London County Council Gazette."
No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 23rd May, 1927, will be considered.
The Council does not bind itself to accept the lowest or any Tender.
MONTAGU H. COX, Clerk of the London County Council. 5336

PUBLIC NOTICES

Administrative County of LONDON.
STREATHAM AND BALHAM STORM RELIEF SEWER EXTENSION.
The London County Council invites TENDERS for the CONSTRUCTION partly in Tunnel and partly in Open Cut of about 1137 Lineal Feet of 5ft. 3in. by 3ft. 6in. BRICK and BRICK and CONCRETE SEWER in Balham High-road, with TWO SIDE ENTRANCES and VENTILATORS; the CONSTRUCTION of a WEIR CHAMBER and the SUPPLY and FIXING of a TIMBER FLAP in an existing chamber, all in the Metropolitan Borough of Wandsworth.
Persons desiring to submit Tenders may obtain the form of Tender and contract, specification, bill of quantities and drawings on application to the Chief Engineer of the Council at the Old County Hall, Spring-gardens, S.W. 1, upon payment of the sum of £5 by cheque or draft to the order of the London County Council. This amount will be returnable only if the tenderer shall have sent in a bona fide Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application and the contract documents may be inspected before payment of the fee.
The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in the "London County Council Gazette."
No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 23rd May, 1927, will be considered.
The Council does not bind itself to accept the lowest or any Tender.
MONTAGU H. COX, Clerk of the London County Council. 5329

The Madras and Southern MAHRATTA RAILWAY COMPANY, Ltd.,
25, Buckingham Palace-road, Westminster, S.W. 1, invite TENDERS for :—
(1) 330,100 STEEL DOG SPIKES for use with B.S. 60, 75, and 90 lb. F.F. Rails (Approximate total weight equals 92 tons).
(2) 184,400 FISH BOLTS with NUTS and WASHERS for use with Rails as above (approximate total weight equals 146 tons).
(3) 47,000 M.S. TIE BARS and 94,000 GIBS and COTTERS for use with Rails as above (approximate total weight equals 695 tons).
Tenders are due in on Tuesday, 17th May, 1927, by 2 p.m. Tender forms obtainable at above address; fee for No. (1) Half a Guinea, Nos. (2) and (3) One Guinea, which is not returnable.
The Directors do not bind themselves to accept the lowest or any Tender. 5323

PUBLIC NOTICES

Ashborne Urban District COUNCIL.
RODSLEY WATER SCHEME.—CONTRACT NO. 5.
CAST IRON PIPES.
The Council invite TENDERS for the MANUFACTURE and DELIVERY of about 300 TONS of CAST IRON REGULAR PIPES and SPECIALS of 7in. and 3in. diameter.
The pipes are to be made in accordance with the British Standard Specification.
Copies of the specification and form of Tender, prepared by the Engineer, Dr. Herbert Lapworth, M. Inst. C.E., 25, Victoria-street, Westminster, may be obtained on application to the Clerk to the Council. The application must be accompanied by the sum of £2, which will be refunded on return of the documents required.
Tenders are to be sent in on the form supplied, and with the specification must be enclosed in a sealed cover, endorsed "Rodsley Water Scheme: Tender for Cast Iron Pipes: Contract No. 5," addressed to and reaching the Clerk to the Council not later than 10 a.m. on Monday, May 16th.
The Council do not bind themselves to accept the lowest or any Tender.
R. WILLIAMS, Clerk to the Council.
Council Offices, Ashborne, Derbyshire. 5379

Ashborne Urban District COUNCIL.
RODSLEY WATER SCHEME.—CONTRACT NO. 6.
PIPE LAYING.
The Council invite TENDERS from experienced contractors for the LAYING of about 3½ MILES of 7in. and 3in. CAST IRON PIPES and SPECIALS, together with VALVES, HYDRANTS, METERS, &c.
The pipes will be supplied by the Council.
The work will extend from the New Pumping Station of the Council at Rodsley to the Service Reservoir in Derby-road, Ashborne, Derbyshire.
Copies of the specification and form of Tender, prepared by the Engineer, Dr. Herbert Lapworth, M. Inst. C.E., 25, Victoria-street, Westminster, may be obtained on application to the Clerk to the Council. The application must be accompanied by the sum of £3, which will be refunded on return of the documents within seven days or after receipt of a bona fide Tender and the documents required.
Tenders are to be sent in on the form supplied and with the specification must be enclosed in a sealed cover, endorsed "Rodsley Water Scheme: Tender for Pipe Laying: Contract No. 6," addressed to and reaching the Clerk to the Council not later than 10 a.m. on Monday, May 23rd.
Facilities for examining the drawings, for inspecting the site and general information may be obtained on application to Mr. D. Powell, M. Inst. M. and Cy. E., Surveyor to the Council, Council Offices, Ashborne, Derbyshire.
The Council do not bind themselves to accept the owest or any Tender.
R. WILLIAMS, Clerk to the Council.
Council Offices, Ashborne, Derbyshire. 5378

County Borough of Halifax.
HALIFAX CORPORATION WATERWORKS.
GORPLE RESERVOIRS.
The Waterworks Committee are prepared to receive TENDERS for the CONSTRUCTION of EMBANKMENTS, &c., for the FORMATION of RESERVOIRS with Ancillary Works in the Gorple Valley, at a distance of about five miles from the Railway Stations of the London, Midland and Scottish Railway at Burnley, and Hebden Bridge respectively. The work will consist of the Excavation and Refilling of the Puddle Trenches, Earthwork Embankments, Waste Weirs, Watercourses, Discharge Tunnels, Valve Shafts and Pipe Lines, of various diameters, including Wells, Meter and Valve Houses, &c. Drawings can be seen and copies of the specification, schedule and form of Tender may be obtained at the offices of Messrs. G. H. Hill and Sons (Manchester), Civil Engineers, 40, Kennedy-street, Manchester, upon the receipt of cheque for Five Guineas. This sum will, after the Corporation shall have come to a decision upon the Tenders, be returned to those parties who shall have sent in a bona fide Tender, shall not have withdrawn the same, and shall have returned the documents and drawings lent to them for the purpose of making up their Tender. A limited number of sets of drawings (uncoloured) are available, and will be lent to persons tendering in priority of application on receipt of the sum of Three Guineas, which will not be returned. Sealed Tenders, endorsed "Tender for Gorple Reservoirs," must be forwarded to the Town Clerk, Town Hall, Halifax, on or before Monday, the 30th May, 1927. The Committee do not bind themselves to accept the lowest or any Tender.
PERCY SAUNDERS, Town Clerk.
Town Hall, Halifax, 27th April, 1927. 5357

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PUBLIC NOTICES

Irish Free State.

MOUNTGARRETT BRIDGE COMMITTEE.
NOTICE TO CONTRACTORS.

Sealed TENDERS for the WORK of RECONSTRUCTING MOUNTGARRETT BRIDGE in Reinforced Concrete with a Steel Opening Span, and for Contingent Works, will be received up to and including the 24th May, 1927, by the Secretary, Kilkenny County Council, at his office, Court House, Kilkenny.

Copies of the plans and specification and approved Tender form can be obtained on deposit of £5 5s. (returnable on receipt of a bona fide Tender) from Messrs. Delap and Waller, 115, Grafton-street, Dublin or from the undersigned. Plans and specification may also be inspected at either office.

Mountgarrett Bridge is situated about two miles above New Ross on the River Barrow, and connects Counties Wexford and Kilkenny.

Tenders will be considered by the Bridge Committee at meeting to be held at the Town Hall, New Ross, on Saturday, 28th May, 1927.

The lowest or any Tender not necessarily accepted.

By Order,
THOMAS DREW,
Secretary to County Council and Bridge Committee.

Court House, Kilkenny. 5336

Metropolitan Water Board.

TENDERS FOR STEEL TANKS, PIPES, &c.

The Metropolitan Water Board invite TENDERS for the SUPPLY of the following STEEL TANKS, PIPES, &c., required in connection with their new works at Kempton :—

Two 84in. dia. Steel Tanks, 61ft. long, in five sections each, ¼in. thick, with 30in., 21¼in., and 18in. flange branches riveted on.
Two 20in. dia. Flange and Spigot Straight Steel Pipes, 10ft., 10in. long, with flange riveted on for branch.
Two 18in. dia. Double Flanged Straight Steel Pipes, 21ft. 1in. long.
Two 18in. dia. Ditto, but only 8in. long.
Two 9in. dia. Double Flanged Steel Pipe Bends 8ft. 9 1-8in. long.

The tanks, pipes, &c., are to be manufactured in accordance with the specification and drawing, and are to be delivered to the site of the works at Kempton Park (Siding, Sunbury, Southern Railway) and riveted at site.

Tenders must be submitted on the official forms, which contain the full specification, and may be obtained, together with a copy of the drawing, from the Chief Engineer by personal application at the offices of the Board (Room 156) or upon forwarding a stamped addressed brief envelope.

Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board and endorsed "Tender for Steel Tanks, Pipes, &c.," must be delivered at the offices of the Board (Room 122) not later than 11 a.m. on Wednesday, 11th May, 1927.

The Board do not bind themselves to accept the lowest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
173, Rosebery-avenue, E.C. 1,
26th April, 1927. 5350

Scarborough Corporation.

NEW IRTON WATER SCHEME.—
CONTRACT NO. 2.
PUMPING MACHINERY.
TO ELECTRICAL AND PUMPING MACHINERY CONTRACTORS.

The Corporation invite TENDERS for the complete INSTALLATION of a HIGH-CLASS ELECTRICAL PUMPING SET in DUPLICATE.

Each pumping set will consist of a Low-lift Vertical Bore-hole Centrifugal Pump driven by an Electric Motor, and Two High-lift Centrifugal Force Pumps with Two Electric Motors. The low-lift pumps to pump 110,000 gallons per hour against a head of about 30ft. inclusive of friction, and the high-lift pumps 55,000 gallons per hour against a head of about 300ft. including friction. The plant is to be complete in all details with certain specified accessories.

Copies of the conditions, specification, schedule of prices and form of Tender, prepared by the Engineer, Dr. Herbert Lapworth, M. Inst. C.E., 25, Victoria-street, Westminster, may be obtained on application to the Town Clerk on or after Friday, April 22nd, 1927. The application must be accompanied by a sum of £5, which will be refunded on return of the documents within seven days or after the receipt of a bona fide Tender and the documents required.

Facilities for inspecting the site and general information can be obtained on application to Mr. Herbert Richardson, M. Inst. W.E., Water Engineer, and Mr. M. B. Mawson, M. Inst. C.E., Resident Engineer, Town Hall, Scarborough.

Tenders are to be sent in on the form supplied and with the annexed documents must be enclosed in a sealed cover, endorsed "New Irton Scheme: Tender for Contract No. 2," addressed to and reaching the undersigned, the Town Clerk, not later than 10 a.m. on Friday, June 3rd, 1927.

Only Tenders from manufacturers experienced in the required type of plant will be considered.

The Corporation do not bind themselves to accept the lowest or any Tender.

SYDNEY JONES,
Town Clerk.

Town Hall, Scarborough,
11th April, 1927. 5281

Egyptian State Railways.

REQUIRED, ONE BOILER INSPECTOR, salary £480 per annum; ONE DISTRICT LOCO. SUPERINTENDENT, salary £540 per annum.

QUALIFICATIONS FOR BOILER INSPECTOR.

Must be between 30 and 40 years of age.

Must have served a regular apprenticeship either with a Railway Company or a firm of Locomotive Builders.

Must be fully qualified to examine and report on the condition of boilers.

Must have had wide experience in Boiler Repair Work.

Must have had experience in the control of men.

In addition to experience in Boiler Shop Work, experience in the Running Department of a Railway would be desirable.

QUALIFICATIONS FOR DISTRICT LOCO. SUPERINTENDENT.

Must have had a good general and technical education and hold an Engineering Degree or be a Member or Associate Member of the Institution of Mechanical Engineers or of the Institution of Civil Engineers.

Must have served a regular apprenticeship in the workshops of an European Railway and have had experience in the Running Department on the foot plate and in Shed Management.

Must be tactful and of firm character, resourceful and capable of controlling men.

Age should be about 30 to 35 years.

Appointment will be in each case for two years.

Applications should be made to
THE CHIEF INSPECTING ENGINEER,
Egyptian Government,
41, Tothill-street, London, S.W. 1,
from whom copy of application form and copy of contract form can be obtained. All communications should be marked at top left-hand corner "Boiler Inspector" or "District Loco. Superintendent." 5341

Mountgarrett Bridge Committee.

CONSTRUCTION OF BRIDGE IN REINFORCED CONCRETE.
CLERK OF WORKS REQUIRED.

APPLICATION is hereby INVITED for the POST of CLERK of WORKS to above Committee. Salary £6 per week.

Applicant must be a fully qualified Engineer and shall be responsible to the Committee through the direction of the Engineer-in-Charge and Engineer.

Application, with references as to qualifications, &c., should be lodged with the undersigned not later than the 24th May, 1927.

The appointment will be considered by the Bridge Committee at meeting to be held at New Ross on Saturday, the 28th May, 1927.

By Order,
THOMAS DREW,
Secretary to Bridge Committee.

House, Kilkenny. 5337

ARNOLD BOOKS

THE STRENGTH OF MATERIALS.
A Treatise on the Theory of Stress Calculations for Engineers.
By JOHN CASE, M.A., F.R.Ae.S.
Lecturer in Applied Mechanics at the Royal Naval Engineering College, Keyham.
552 pages, with 398 Diagrams. 30s. net.

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By G. C. WELLS and A. S. CLAY, B.Sc.
SECOND EDITION. viii + 227 pages, 71 illustrations. Small 8vo. 8s. 6d. net.

THE PRACTICE OF RAILWAY SURVEYING AND PERMANENT WAY WORK.
By S. W. PERROTT, M.A.I., M. Inst. C.E., Professor of Civil Engineering in the University of Liverpool, and F. E. G. BADGER, A.M. Inst. C.E. 30s. net.
"A model in every way of what such a work should be."—*Railway Engineer.*

MODERN METHODS OF WATER PURIFICATION.
By JOHN DON, F.I.C., A.M.I. Mech. E., and JOHN CHISHOLM, A.M.I Mech. E., Engineer and Manager of the Airdrie, Coatbridge and District Waterworks.
SECOND EDITION. xviii + 398 pages, 106 illustrations. 16s. net.

STRENGTH AND STRUCTURE OF STEEL AND OTHER METALS.
By W. E. DALBY, F.R.S., M. Inst. C.E., M.I. Mech. E., London University Professor of Engineering at the City and Guilds Engineering College of the Imperial College of Science and Technology.
With 169 Diagrams, including 38 plates from original microphotographs. 8vo. 18s. net.

GENERAL ASTRONOMY.
By H. SPENCER JONES, M.A., Sc D., M.R.E., H.M. Astronomer at the Cape of Good Hope.
THIRD IMPRESSION. viii + 392 pages, with 102 Diagrams and 24 Plates. 21s. net.

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EXCEPTIONAL VALUE IN
SHAPING MACHINES
A SELECTION FROM OUR CLEARANCE STOCK.

Stockbridge 16″ Crank, cone pulley (GOOD WORKING ORDER). £165.
Belgian (Van Droogenbroeck) 16″, heavy duty, cone pulley (NEW). £125.
Wotan 21″ Crank, Type E 6, cone pulley (NEW). £125.
Gould & Eberhardt 16″, cone pulley (GOOD WORKING ORDER). £140.
Gould & Eberhardt 20″, cone pulley (GOOD WORKING ORDER). £170.

(OFFERED SUBJECT TO PRIOR SALE.)

Our Machine Tool Clearance List contains a large number of Bargains, New, Re-conditioned and Second-hand. Send for your Copy to-day.

PUBLIC NOTICES

Municipal Council of Sydney.

NEW SOUTH WALES, AUSTRALIA.

Sealed and endorsed TENDERS will be received by the undersigned until 3 p.m. on the 18th July, 1927, for the ERECTION of a NEW REFUSE DESTRUCTOR at Prymont, Sydney, in accordance with Specification No. 1/27, prepared by the City Cleansing Engineer.

Specifications are issued free of cost to bona fide tenderers, and copies may be obtained from the City Cleansing Engineer, Town Hall, Sydney; Mr. J. Davis, Consulting Engineer, 100, Victoria-street, Westminster, S.W. 1, England, and the Australian Trade Commissioner, 34, Whitehall-street, New York City, U.S.A.

The lowest or any Tender not necessarily accepted.

Tenderers are to note that they must pay their cash deposit direct into the City Treasury, Town Hall, Sydney, and not enclose it with their Tender, otherwise their Tender will be rejected as informal.

W. G. LAYTON,
Town Clerk.

Town Hall, Sydney.
4th March, 1927 5333

Epsom Union.

NON-RESIDENT ASSISTANT ENGINEER.

The Guardians of the Epsom Union REQUIRE the SERVICES of an ASSISTANT ENGINEER at the Guardians' Institution, Dorking-road, Epsom.

The salary will be after the rate of £120 per annum, rising by annual increments of £5 to a maximum of £180 per annum, subject to approved service.

Applications, on forms to be obtained from the undersigned, must be received by me not later than first post on Wednesday, the 4th May, 1927.

The appointment will be subject to the provisions of the Poor Law Officers' Superannuation Act, 1896, and to the National Insurance Acts.

The person appointed must be a qualified plumber with domestic engineering experience, and will be required to assist the Engineer and make himself generally useful.

Previous experience in an Institution will be a recommendation.

By Order,
ALICK G. EBBUTT,
Clerk.

"Mead House," South-street, Epsom,
21st April, 1927. 5338

PUBLIC NOTICES

Sheffield Corporation Tramways and Motors.

MECHANICAL SUPERINTENDENT.

The Sheffield Corporation Tramways REQUIRE the SERVICES of a fully trained MECHANICAL SUPERINTENDENT for their Tramway and Motor Omnibus Department.

Candidates must have had theoretical training and education and also practical experience in a similar and responsible position.

Salary and bonus £364 17s. 7d., rising in twelve months to £390 2s. per annum, according to E.P.E.A. scale.

Terms and particulars of appointment, together with application forms, may be obtained from the undersigned.

Applications, on the forms provided, to be delivered not later than 10th May, 1927.

A. R. FEARNLEY, M. Inst. A.E.,
General Manager.

Division-street, Sheffield,
April 20th, 1927. 5349

Wanted, Engineer for Oilfield

in the Punjab.

Must be capable of taking charge of Boilers of various sizes and have good practical mechanical training.

Also ENGINEER, capable of running Gas and Oil Engines of various types and with good general training.

Drawing-office experience a recommendation.

Age 22-26, unmarried.

First agreement 3 years.

Salary, excluding allowances but including Provident Fund, Rs. 3900, Rs. 4550, and Rs. 5200 per annum.

Passage paid; medical expenses and furnished quarters free.

Reply, giving age, full particulars of experience and copies of testimonials, to "Z.D. 173," c/o Deacon's Advertising Agency, Fenchurch-avenue, London, E.C. 3. 5327

Wanted, for Service in North Borneo,

young PUBLIC WORKS ASSISTANT ENGINEER, single, with some practical experience of General Municipal Engineering.

Apply by letter, with COPIES of testimonials, to
THE SECRETARY,
British North Borneo (Chartered) Company,
5345 17, St. Helen's-place, London, E.C. 3.

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, a STRUCTURAL ENGINEER, to Fill a Senior Post with a British Firm in India who have Structural Steel and General Engineering Works. Should have A.M.I.C.E. or equivalent qualifications. Must have had good technical and practical training, also drawing-office, workshop and commercial experience. Age 30 to 35. Good salary and prospects to a suitable man.—Address, P3092, The Engineer Office. P3092 A

WANTED for London District, a SHEET METAL WORKER, age about 30. Must be first-class man and know all branches of his trade. Give full particulars of experience by letter.—Address, 5342, The Engineer Office. 5342 A

WANTED, MECHANICAL ENGINEER as Assistant Works Manager, Birmingham District. Must be practical and experienced with workmen. Starting salary about £350. Selected man will be required to start at once.—Address, P3095, The Engineer Office. P3095 A

WANTED, Reliable MAN, to Take Charge of Electric Furnace Plant for the manufacture of steel castings. State age, experience, salary required, &c.—Address, 5321, The Engineer Office. 5321 A

WANTED, SIX First-class COMBUSTION ENGINEERS; experience Pulverised Coal essential.—Apply by letter, giving full qualifications, experience, and salary required, BOLTON and PARTNERS, Limited, 3, Iddesleigh House, Caxton-street, S.W. 1. 5360 A

A COMPANY Specialising in an Apparatus for the utilisation of steam in textile and other factories REQUIRES the SERVICES of a GENERAL MANAGER having a thorough knowledge of this branch of engineering, also experienced in controlling, estimating and selling staffs and interviewing clients.—Address, stating age, experience, and remuneration required, 5364, The Engineer Office. 5364 A

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HYDRAULIC ENGINEER, with Proper Drawing office and practical experience relating to Water Power and Irrigation Work, REQUIRED as Head of Drawing-office, London.—Address, 5367, The Engineer Office. 5367 A

MANAGER REQUIRED for Large Engineering Works manufacturing Gas and Chemical Plant, and comprising constructional yards, machine shops, foundries, &c.—Write, stating training and experience, age, salary, &c., to Box Z.X. 167, care of Deacon's Advertising Agency, Fenchurch-avenue, London, E.C. 3. 5325 A

PRODUCTION ENGINEER WANTED as Assistant to Works Manager in Works possessing own foundries, machine shops, &c., and employing about 1000 men.

Applicants should have practical experience in planning and modern methods of works organisation, both as regards quantity production of standard lines, also the handling of large work made specially to order.

Address, giving all details, past experience and training, and stating salary expected, to BM/BA3A, London. 5313 A

REPRESENTATIVES with Engineering Training REQUIRED to push Electric Boiler Scaling Tool in Midlands, Yorkshire, East and South-West Coasts. Good commission. State area covered, age, experience.—Address, P3105, The Engineer Office. P3105 A

RESIDENT ENGINEER WANTED as MANAGER of old-established industrial undertaking. Salary £350. Preference to one who can invest £500.—Address, P3116, The Engineer Office. P3116 A

WILLIAM ASQUITH (1920), Ltd., Highroad Well Works, Halifax, invite APPLICATIONS for POSITIONS as AREA REPRESENTATIVES. Must have thorough Machine Tool knowledge, good experience and connection.—State fullest particulars, age, salary, &c., in writing, in strict confidence, to GENERAL MANAGER, as above. 5376 A

WANTED, as ASSISTANT CHIEF DRAUGHTSMAN, a thoroughly competent MAN to undertake calculations for and take charge of General and Detailed Designs of various types of Main Engines, but more particularly of Designs of Turbines and Gearing. Must have had a good technical education combined with practical experience in the works of a marine engineering firm; also must have held a responsible position in drawing-office, preferably as assistant-chief or chief draughtsman.—Apply by letter to WILLIAM DENNY and BROTHERS, Ltd., Engineering Dept., Engine Works, Dumbarton, stating age, salary required, and full particulars of qualifications. P3112 A

WANTED, DRAUGHTSMAN, Experienced in the design of High-speed Crude Oil Engines. Good salary for suitable applicant.—Address, giving fullest particulars, 5348, The Engineer Office. 5348 A

WANTED, DRAUGHTSMAN for Industrial Factory in the Midlands. First-class Chemical Works experience.—Address full particulars, 5365, The Engineer Office. 5365 A

WANTED, TWO First-class ENGINEERING DRAUGHTSMEN, accustomed to the lay-out and design of Water-tube Boilers and their Access aories.—Address in first instance, stating experience, age, and salary required, 5369, The Engineer Office. 5369 A

CHIEF DESIGNER WANTED.—A Well-known FIRM of CRANE BUILDERS in the North of England DESIRE the SERVICES of a thoroughly experienced LEADING DRAUGHTSMAN for Cranes of all types and similar Engineering Work.

Only those capable of designing without supervision need apply.

A competent man will be assured of a permanent position and progressive salary.

State age, full details of experience, and when at liberty.

Address, 5236, The Engineer Office. 5236 A

CHIEF DESIGNER WANTED, Preferably with experience in the design of Heavy Road Vehicles driven by steam or crude oil engines. Must be competent to exercise efficient control over drawing-office. Give full details of experience, stating age, salary required, and when at liberty.—Address, P3097, The Engineer Office. P3097 A

CHIEF DRAUGHTSMAN REQUIRED by Large Firm of Constructional Engineers in Manchester. Must have previously held similar position and be capable of taking full control.

Salary £400/450 per annum, according to ability.

Address, stating full particulars, details of experience, when at liberty, &c., 5314, The Engineer Office. 5314 A

DRAUGHTSMAN, Good Junior, for Temporary Position in Kent, experienced in Ferro-concrete and Structural Steel. Sound technical education essential.—Address, 5319, The Engineer Office. 5319 A

DRAUGHTSMAN WANTED for Medium-weight Machine Tools.—Apply by letter, stating education, experience, and wages required, to WEBSTER and BENNETT, Ltd., Foleshill, Coventry. 5375 A

FIRST-CLASS DRAUGHTSMAN REQUIRED for London. Essential capable of preparing designs of Electric Jib and Steam Breakdown Cranes for estimating purposes.—Apply, stating age, experience, and salary required, Box No. 3435, c/o Browne's, 39, Tothill-street, S.W. 1. 5345 A

For continuation of Small Advertisements see page 3.

A Seven-Day Journal

The Progress of Civil Aviation.

THE recently issued report on the progress of civil aviation shows that during the year 1926 British commercial aircraft engaged on organised air transport services flew a total distance of 840,000 miles in 4777 flights, during which they carried 16,775 passengers and 679 tons of cargo. Both the number of passengers carried and the quantity of goods handled surpass the record of any previous year. It appears too that the machines were operated more efficiently than in 1925, for the number of passengers carried per machine flight was 3·5, as compared with 2·5 in the preceding twelve months. These figures might, we think, be included as a regular feature in future reports and not be left for the reader to extract for himself. An examination of the records for previous years shows that the number of passengers carried per machine flight has varied between 2·0 and 3·25, except in 1921, when it reached the high figure of 5·25. In flying for hire otherwise than on the organised routes British machines last year made 42,843 flights, flew 215,000 miles and carried 81,909 passengers. Of the flights between Great Britain and the Continent 52 per cent. were made by British machines, and of the passengers carried to or from the Continent 61 per cent. were transported in British machines. During the year nearly a million pounds' worth of goods were imported into the United Kingdom by aircraft and a like value exported by the same means. Bullion and coins to the value of £307,000 were imported by air and exported to the value of £7,976,000. Of the scheduled flights on the British subsidised air services 82 per cent. were completed, 76 per cent. being completed without interruption. Of the flights actually commenced 97 per cent. were completed, 90 per cent. being completed without interruption. There were no fatalities or injuries either to the passengers or crew on the organised air transport services during the year. In other forms of flying one fare-paying passenger was killed.

The Deaths of Three Engineers.

WE have, with regret, to place on record the deaths of three engineers, who, curiously enough, were all of them identified to a greater or less extent with hydraulic engineering. They were Mr. Arthur Hill, C.I.E., late Chief Engineer for Irrigation in the Bombay Presidency; Mr. Frederick Storr, who was closely connected with both the Chester and the Wrexham and East Denbighshire Waterworks Companies; and Dr. A. W. Brightmore, who was an Engineering Inspector in the Ministry of Health, but who was, earlier in his life, connected with both the Liverpool and Birmingham water undertakings. Mr. Hill, who was sixty-nine years of age, had a distinguished career in India. After passing through Coopers Hill College, he entered the service of the Public Works Department, Bombay, in 1880, as an assistant irrigation engineer, and rose in the service till, in 1906, he was made superintending engineer, becoming then Chief Engineer and Joint Secretary to the Department. During his occupancy of those positions he was largely responsible for the vast irrigation works which were carried out in the Bombay Presidency in accordance with the recommendations of the Commission appointed by Lord Curzon. He retired in 1913. Mr. Storr was looked upon as being one of the most eminent water engineers in the North of England. His connection with the Chester and the Wrexham and Denbighshire Waterworks Companies was very intimate. He was deputy chairman of both of them and was consulting engineer to the Chester undertaking, while he had been secretary and engineer to the Welsh company for considerably over half a century. He died at the age of seventy-seven. Dr. Brightmore was a considerably younger man than either Mr. Hill or Mr. Storr, being only sixty-two at the time of his death. He was first engaged, under the late Dr. G. F. Deacon, as resident engineer on part of the Vyrnwy waterworks, and later, under the late Mr. James Mansergh, F.R.S., on the Elan Valley works in a similar capacity. Subsequently, before going to the Ministry of Health, he was Professor of Structural Engineering at Coopers Hill. At one time, too, he interested himself in the design of commercial motor vehicles.

Mechanization in American Industry.

IN speaking as the guest of the Manchester Chamber of Commerce at a luncheon which was held on Friday of last week, April 22nd, Mr. A. B. Houghton, the American Ambassador to Great Britain, made an interesting reference to the part which is played by machinery in the prosperity of American industry as we know it to-day. After recalling the undoubted advantages possessed by America in her abundant supplies of native raw materials, and the freedom in industry both as regards movement from place to place and the opportunities which presented themselves in different grades of service, Mr. Houghton stated that against that general background had to be placed the fact that Americans were making more use of machinery and mechanical aids to production than any other people. A start had as yet only been made, but already the point had been reached at which behind every industrial worker stood an invested capital of £1200. That resulted, he continued, in some four primary horse-power being put at the disposal of each worker. If one horse-power was roughly assumed to represent the power of ten men, then the labour of each industrial worker was by the use of machinery increased forty-fold. If it were assumed that an average of 20,000,000 men were engaged in industrial production in America, then it could be said that those workers were doing the work of at least 800,000,000 unaided men. Not only was the work being done, but that work created opportunities of other work and the enormous output resulted in high wages and reduced costs of production. Referring to the relations between capital and labour in America, Mr. Houghton said that he thought that the idea that capital and labour were best served and best rewarded by a mutual attitude of suspicion and distrust was rapidly being left behind and had been replaced by full and willing co-operation in the interests of maximum production.

A Subsidy for Six-wheeled Lorries.

As forecast by Captain C. H. Kuhne in his paper on "The Development of Mechanical Vehicles for Load-carrying Duty in the Army," presented before the Institution of Mechanical Engineers on Friday, March 11th, which was reprinted in our issues of March 18th and 25th, the War Office has now extended its subsidy scheme involving a payment of £40 per annum for three years to vehicles of a new class known as the W.D. "Medium" six-wheeled type. The subsidy scheme referred to has so far covered a thousand lorries of the four-wheeled type, and it is hoped that equal success will attend this new development. As the result of experiments which have been carried out over a considerable period, the specification for the "Medium" six-wheeler has been drawn up to provide a vehicle which shall be capable of reasonable cross-country service, combined with the maximum efficiency when used on ordinary road service. The vehicle has been designed to carry heavier loads than could be transported by a four-wheeled vehicle of similar dimensions and engine power, while it can travel fast with a normal load and is capable of dealing with an added trailer load at slower speeds. The design is said to be economical as regards both fuel consumption and maintenance costs. As Captain Kuhne revealed in the course of presenting his paper, this new type of lorry is now being manufactured by leading makers of commercial vehicles. The Chief Inspector of Subsidised Transport at 14–16, Grosvenor-gardens, S.W. 1, will give any desired information to intending purchasers of the new lorries, while specifications and other technical information will be supplied to manufacturers on application to the Under-Secretary of State at the War Office, London, S.W. 1.

The Retirement of Mr. L. D. Wingate.

FEW marine engineers, we believe, have a longer record of service than Mr. L. D. Wingate, who recently retired from the position of general manager to Richardsons, Westgarth and Co., Ltd., of West Hartlepool. Mr. Wingate had been associated with the present company and its predecessor, Thos. Richardson and Sons, for a period of over forty-two years. He worked under the late Mr. Wylie, who was succeeded by the late Mr. D. B. Morison. Since the formation of the present company no less than 764 vessels have been engined by the firm, representing an output of marine engines aggregating some 1,730,000 I.H.P. Mr. Wingate dealt in detail with practically all this work. At a dinner recently held at West Hartlepool, which was attended by the directors and staff of the firm's West Hartlepool, Middlesbrough and Sunderland works, tribute was paid to the services which Mr. Wingate had rendered to the company. Mr. George Clark, managing director, referred to the ability of Mr. Wingate as an engineer and his sterling qualities both as a colleague and a friend; and Mr. Henry Barnes, the secretary of the company, mentioned his kindly and personal interest in the foremen, workmen, and apprentices. In reply, Mr. Wingate expressed his regrets at parting from the firm and said that under the able management of Mr. George Clark and with the support of a loyal staff prosperity would, he felt assured, again return to the firm with which he had so long been connected.

Completion of H.M.S. Nelson.

THE new battleship Nelson left the Armstrong yard at Walker-on-the-Tyne early on the morning of April 22nd, and arrived at Spithead last Monday evening. It is understood that various machinery trials were held during the voyage. She subsequently went into dock at Portsmouth to be prepared for her official trials, which are expected to last about six weeks. The vessel is due to join the Atlantic Fleet in June. She is at present under the command of Captain the Hon. M. R. Best, who will be relieved on July 1st by Captain S. J. Meyrick. As the keel of the Nelson was laid in December, 1922, her construction will have occupied four and a-half years. Progress was delayed from time to time by industrial disputes, notably by the boilermakers' lock-out in 1923 and the coal stoppage last year. Whether measured by her standard displacement of 35,000 tons or her full-load displacement of nearly 40,000 tons, the Nelson is the largest battleship yet constructed for any navy. She is also the second heaviest warship afloat, her only superior being the battle-cruiser Hood, which has a normal displacement of 41,200 tons. In weight of armament the Nelson is unique. Not only does she carry nine 16in. guns, against the eight pieces of this calibre mounted in certain foreign ships, but her guns are believed to be considerably more powerful as to weight of projectile and muzzle velocity than the American and Japanese marks. Another distinctive feature of the Nelson is her very large fuel oil capacity, viz., 4000 tons. The system of armour and sub-surface protection is known to embody the most advanced principles. Her total cost, including guns, is officially returned as £6,483,879. She and her sister ship, Rodney, were designed by Sir E. T. d'Eyncourt, late Director of Naval Construction.

Engineering Conference at Manchester.

ON Sunday afternoon last, April 24th, Mr. L. E. Mather, chairman of Mather and Platt, Ltd., and president of the Manchester Engineering Conference, summed up the speeches made at the joint conference between employers and employees in the engineering industries, the programme of which will be found in our issue of April 15th. Mr. Mather said that attendance at the conference had been well maintained, and that he thought the occasion had been really helpful by developing further that friendly spirit which the Manchester Engineering Conference had already evoked in the district. The discussions had been characterised by their quality and pointedness and the aim of the promoters of the conference had been, he thought, realised. Mr. W. L. Hichens and Mr. W. M. Citrine had given excellent addresses on the subject of economic production from two very different standpoints. In another address Mr. A. Ramsay had impressed upon the conference the idea that the future of the engineering industry lay principally in the overseas Dominions of the British Empire. The question of broadening the basis of capital ownership had also been discussed, and Mr. T. Chadwick had raised the issue as to whether in the future industry was to be carried on for profit or for service. Sir Harold Morris, K.C., had emphasised the idea that arbitration should be voluntary and not compulsory, while Mr. T. Kaylor apparently regarded it as a necessary evil. Mr. J. T. Brownlie had reminded the conference that the time had now arrived for a new outlook on the part of both trade unions and employers, and he had recalled an almost forgotten report of 1919 on a national industrial council. Sir Holberry Mensforth had made a forceful and useful contribution to the same discussion. In dealing with works committees Mr. E. J. Fox had given a really practical address, while Mr. S. Ratcliffe had brought out the question of the foreman. Several visiting engineers expressed their appreciation of the conference.

The New P. and O. Liner.

THE new liner for the Peninsular and Oriental Steam Navigation Company, which was referred to in a Journal note of March 18th, is to be built by Alexander Stephen and Sons, Ltd., of Linthouse, Glasgow, and she promises to be a vessel of exceptional interest. Her tonnage will be about 19,000 gross, and she is to be propelled by high-pressure twin-screw turbine machinery with electric transmission to the propellers. The turbines and alternators are to be constructed by the British Thomson-Houston Company, Ltd., of Rugby, and all auxiliaries will be electrically operated. Steam will be generated at a pressure of 400 lb. per square inch in Yarrow water-tube boilers, and supplied to the turbines at a pressure of about 350 lb. The total designed output of the propelling machinery will be 17,000 S.H.P., which will give the ship a speed of about 19 knots. We understand that the deck machinery will be worked electrically on the Austin constant current system. The new liner will be the first large passenger vessel built in Great Britain to be fitted with the electric drive.

The Nag Hamadi Nile Barrage.

NEW interest has been aroused in the irrigation schemes which are to be carried out by the Egyptian Government in Egypt proper, by the recent news from Cairo that the tender of Sir John Jackson, Ltd., of Westminster, for the construction of the new Nile barrage at Nag Hamadi is the lowest of the many tenders for the work which have been submitted. The figure mentioned is £1,976,621 in Egyptian currency, or over £2,000,000 sterling. The site of the proposed barrage is some 30 miles below Luxor, and the plans for the new work are in the hands of Messrs. Coode, Fitzmaurice, Wilson and Mitchell, of Westminster, who were the consulting engineers for the Sennar Dam and have been retained by the Egyptian Government for the new work. Both Mr. M. F. G. Wilson, M. Inst. C.E., the senior partner in the firm, and Mr. A. G. Vaughan-Lee are now in Egypt, and will return to England shortly.

The Railway and Urban Improvements at Piccadilly Circus.

No. I.

THE WORKS AS RAILWAY AND MUNICIPAL IMPROVEMENTS.

The works now being carried out by the London Electric Railway Company at Piccadilly Circus have as their primary objects:—(*a*) The improvement of access to two tube stations—the "Piccadilly" and the "Bakerloo"; (*b*) the replacement of two booking offices by a single and much more commodious hall; and (*c*) provision for more convenient transit between the Bakerloo and the Piccadilly lines. But, as suggested by the title chosen for this article, the incidental works of urban or municipal improvement may be regarded as of equal or even greater importance, since they will affect the convenience and expenses of a far larger number of persons per annum than that advantaged by the improvement as a matter of underground railway travel. Moreover, some of the works pertaining to the railway improvement, will also benefit the general public in other respects. Of the latter, the most important is the system of passenger subways by means of which the Circus, or any part of its periphery, may at all times be crossed in safety and freedom from splashing. The pipe subways will provide for perennial savings in the direct and indirect costs of street excavations and in the expenses now entailed by repairs and alterations to pipes and cables within the area of the Circus.

In the present instalment of this article the works are described in their railway traffic and civic aspects, features which can be grouped as of civil engineering and structural interest being reserved for description in the second instalment.

The whole of the works have been designed and are being carried out under the immediate direction of Mr. H. H. Dalrymple-Hay, M. Inst. C.E., the consulting engineer of the railway. The contractors for the present contract, including escalator tunnels and pipe subways, are John Mowlem and Co., Ltd. For some of the preliminary work, a contract, now concluded, was made with John Cochrane and Son.

The Works as a Railway Improvement.

The direct purpose of the undertaking is to provide, under the roadway of the Circus, a large booking hall, from which there will be access, by means of escalators and short flights of steps, to the two existing stations, one on the Baker-street and Waterloo Railway and the other on the Piccadilly Railway. As affecting passengers from the Circus, the improvement is important. In the first place the intending passenger will not need to consider or inquire which line will serve him the better as the first stage of a roundabout journey, until he is under cover in a booking hall common to both. Next, whereas from most points of arrival by road neither station is very conspicuous among the many signs competing for attention, an entrance to the new booking hall may be made from either footway of any street except at one corner—the junction of Glasshouse-street and Shaftesbury-avenue. Thus, from only two arrival points out of seven will any crossing of a street be necessary, an average of one-quarter crossing per arrival point against the present average of 1½, in case of the Bakerloo Station. The descent from the street to the booking hall will average about 14ft. The importance of the works in relation to tube passenger traffic may be judged from the fact that provision is being made for some 50,000,000 passengers per annum, or a weekday average of about 150,000.

From the booking hall the passenger will first descend 42ft. by an escalator, and from that point he may reach the Bakerloo platforms by descending 21ft. by an escalator and 10ft. by stairs, or he may reach the Piccadilly line platforms by an escalator descent of 39ft. and 12ft. by stairs. He therefore descends 24ft. by stairs out of a total of 87ft. in one case, and, in the other case, 26ft. by stairs out of a total of 107ft., the average of 14ft. from the street to the booking hall being included in both cases. As the only alternative he may climb up or down 87ft. or 107ft. by the spiral staircase provided for persons who cannot use escalators.

These stations will not, therefore, be available for that small proportion of travellers, including some of the lame and most of the aged, who can neither use escalators nor face a spiral ascent or descent of over 80ft., vertical measurements.

Allowing for some reduction in the walking distance before the booking office is reached, the amount of walking on the level necessary in order to reach the platforms may be considered quite moderate, as tube stations go.

Fig. 1 is a sectional plan, showing the seven staircases giving access to five subways leading to the booking hall. The widths of these subways, ranging from 20ft. to 8ft., have evidently been the subject of careful consideration of the numbers of persons likely to enter at the several points in a given time. The booking hall will have a central oval about 90ft. by 80ft. structurally, 78ft. of its length being inside the passimeters. On its circumference there will be one ring of the columns supporting the roof. The oval is allotted to railway purposes including, of course, as the main feature, the upper ends of the escalators.

Around the oval will be the 15ft. public gangway, on the outer circumference of which, and forming the only demarkation shown between it and a 5ft. gangway, there will be the other ring of columns supporting the roof. This completes the apportionment of the area except for the remaining 6ft. ring, which will be occupied by showcases, except between subways No. 4 and No. 5. The outer ring of columns might, it may be suggested, be supplemented by posts, in order to affect a more continuous demarkation between the fairway and the areas properly available for the use of persons who are studying the contents of the showcases. The ends of these spaces, where they emerge at the corners upon the entrances from subways, will probably be entirely blocked to prevent the eddying currents of leisured people from impinging upon the streams of passengers entering and leaving the subways.

A schematic sectional view is furnished in Fig. 2. The stratum of gravel varies somewhat in depth, from about 17ft. to about 22ft.; over most of the area it is about 20ft. Two of the escalators are shown, with the operating machinery indicated in outline. The section passes through the pipe subway—to be described later—at two points. The sewers shown in the right-hand half of the drawing are at depths of about 50ft. and 30ft.

The Works as a Municipal Improvement.

The direct and indirect effects of the works in increasing the civic efficiency of Piccadilly Circus will be important. The circulating area of the booking hall, a ring in which loiterers will not be treated as trespassers, will to some extent relieve adjacent footways, especially on wet days, while the radial distribution of passengers emerging from the tubes will have a similar effect. Pedestrians will find in the subways a convenient means of making any crossing in which more than one street end is involved, in which cases the distances to be traversed will often be less than those necessary for safe crossing on the level, while crossings involving more than a third of the whole circuit will be much shorter.

Considering also the further use that will be made of the subways when the streets are in a splashy condition, it is evident that the crowding of pedestrians at street corners will be much reduced and hold-ups of wheeled traffic be lessened in number or duration. On the average of the year, wheeled traffic will be further facilitated as the result of the provision of

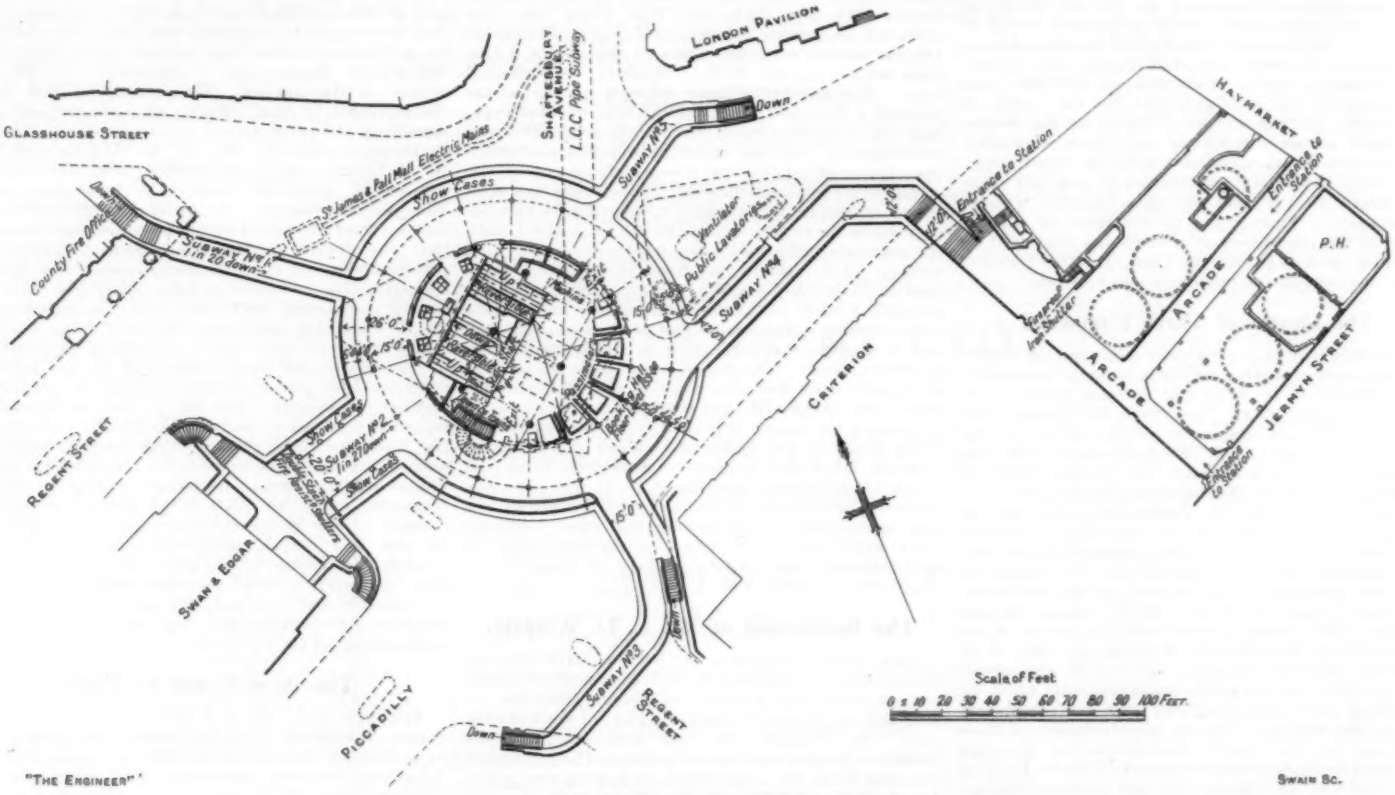


FIG. 1—BOOKING HALL AND PASSENGER SUBWAYS

The Pipe Subways.

Of greater importance as a civic improvement is the effect which the pipe subways will have in the matter of the costs of access and maintenance in respect of pipes and cables. It is unnecessary to describe in detail the nature and location of these subways, since this information is precisely conveyed by Figs. 3 and 4. The various pipes and cables now entering the Circus from the converging streets will in each case be intercepted and diverted to "pipe shafts" and subways in which they will be accessible, re-entering the ground at another "interceptor." An exception is made in the case of the gas mains, all of which will be left in the ground. In Shaftesbury-avenue the various conduits are already arranged in a subway, now reaching to a point south-west of the new stair shaft. The portion from X (not to be confused with XX in Shaftesbury-avenue) to Y is to be removed, and a "pipe shaft," No. 3, will provide the connection with the circuiting subway A B C at Chamber No. 3. In order to intercept the pipes which enter the Circus from Glasshouse-street it has been sufficient to place an interceptor to one side of the carriageway, while in Piccadilly the width to be intercepted is, of course, less than that of the present widened street. In the other cases the interceptor lies across the width of the carriageway.

From each of these interceptors a pipe shaft, having in some cases a portion which is virtually a branch subway, will connect with the main or circuiting subway A B C. Thus the whole area of the Circus proper

RAILWAY AND URBAN IMPROVEMENTS AT PICCADILLY CIRCUS

MR. H. H. DALRYMPLE-HAY, M. INST. C.E., LONDON, ENGINEER

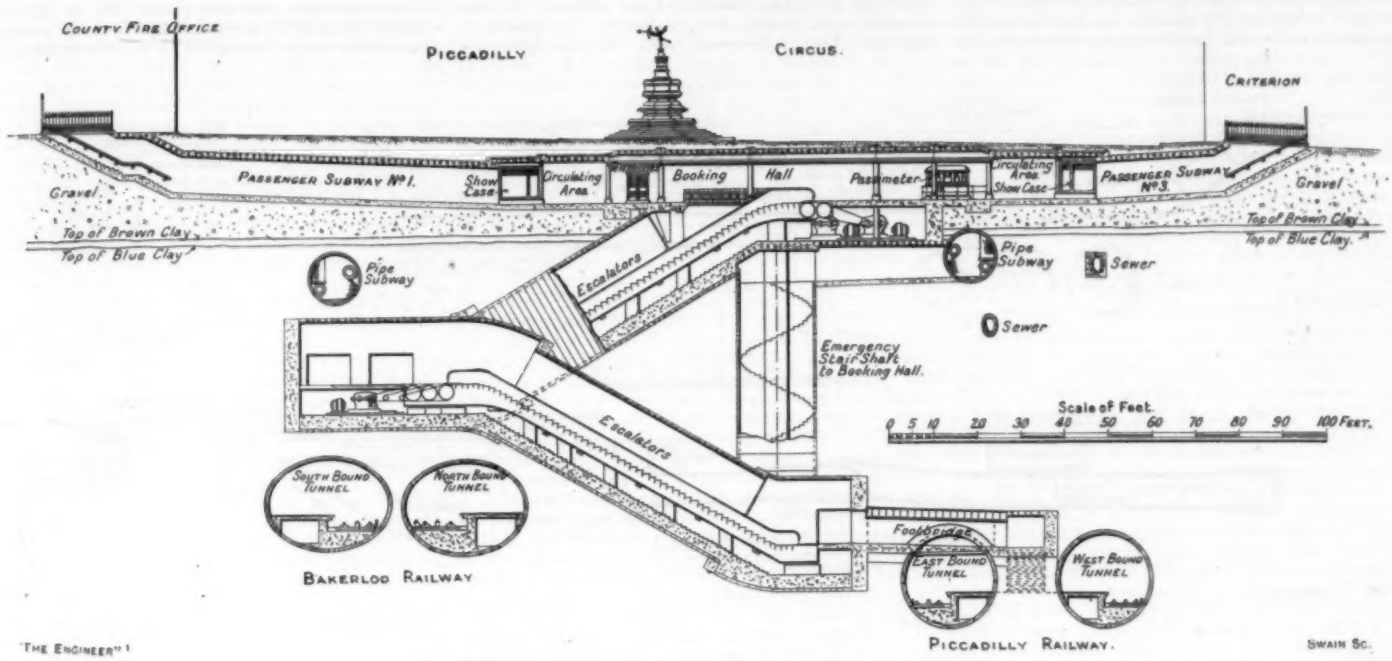


FIG. 2—SCHEMATIC SECTION OF PICCADILLY CIRCUS AND STATIONS

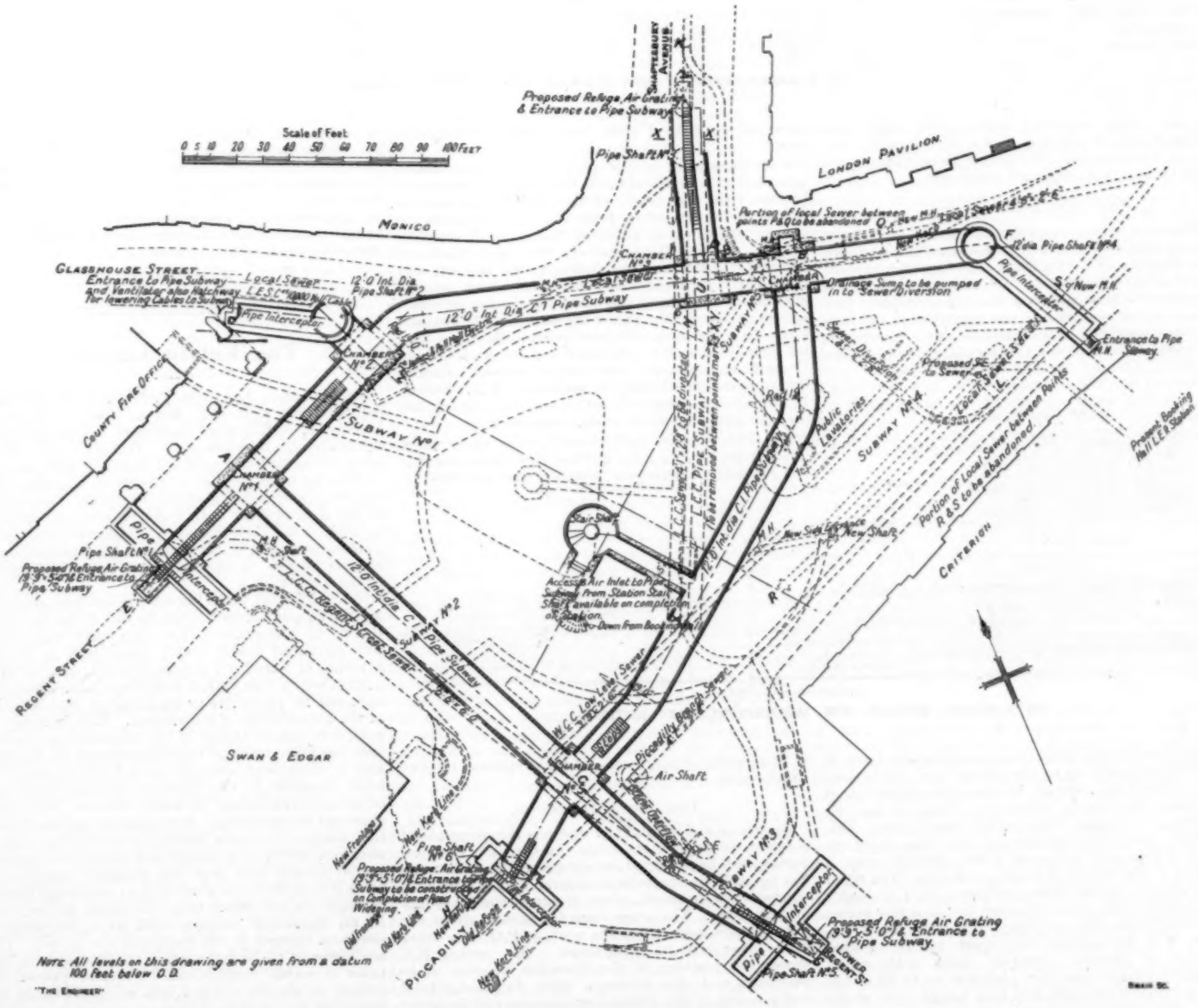

Scale of Feet.
0 5 10 20 30 40 50 60 70 80 90 100 Feet
Shaftesbury Avenue
Proposed Refuge Air Grating & Entrance to Pipe Subway
Pipe Shaft No 4
London Pavilion
Monico
Glasshouse Street
Entrance to Pipe Subway and Ventilator also Hatchway for lowering Cables to Subway
Local Sewer
12'0" Int. Dia. Pipe Shaft No 2
12'0" Int. Dia. C.I. Pipe Subway
Pipe Interceptor
Chamber No 2
Chamber No 1
Subway No 1
County Fire Office
Regent Street
Pipe Shaft No 1
Proposed Refuge Air Grating (9'9"×5'0") & Entrance to Pipe Subway
Pipe Interceptor
12'0" Int. Dia. C.I. Pipe Subway
Swan & Edgar
Piccadilly
Old Kerb Line
New Kerb Line
Pipe Shaft No 6
Proposed Refuge Air Grating (9'9"×5'0") & Entrance to Pipe Subway to be constructed on Completion of Road Widening.
Old Footway
New Footway
Portion of local Sewer between points P & Q to be abandoned
New M.H.
Chamber No 3
Ordinance Sump to be pumped in to Sewer Diversion
12'dia Pipe Shaft No 4
Pipe Interceptor
Sewer New M.H.
Entrance to Pipe Subway.
Proposed Sewer to Sewer
Local Sewer
Public Lavatories
Subway No 4
Portion of Local Sewer between points R & S to be abandoned
Present Booking Hall L.E.R. Station
Criterion
Access & Air Inlet to Pipe Subway from Station Stair Shaft available on completion of Station
Stair Shaft
New Subway Entrance
New Shaft
Piccadilly Tube Sewer
Air Shaft
Subway No 3
Proposed Refuge Air Grating (9'9"×5'0") & Entrance to Pipe Subway.
Pipe Shaft No 5
Lower Regent St
Note: All levels on this drawing are given from a datum 100 feet below O.D.
"The Engineer"

FIG. 3—PIPE SUBWAYS AND INTERCEPTORS

and small portions of the adjoining streets will be freed from breaking-up operations.

The pipe subways are of cast iron, 12ft. in diameter, composed of rings of a normal type, each made up of flanged elements, and will accommodate the pipes and cables each in a predetermined alignment along a series of supporting racks. In order that the work of changing over may readily and surely be carried out the proper lengths of pipe and all the bends and "specials" necessary for precise adaptation to the alignment in each case have been specified and the rails at both ends, rampwise, to a distance of 5ft. 4in. The end of the concrete ramp is 1½in. below the surface of the wood block paving on which it abuts, thus allowing for the asphalt carpet of 1½in. thickness which covers the whole structure. The ramps have therefore very moderate slopes and the whole affair offers no appreciable impediment to traffic. Underneath, in the excavation for the interceptor, light timbering provides sufficient local support for the concrete road crust, the underside of which is exposed. The permanent roofs of the interceptors will consist of steel joists embedded in concrete.

The alignments of the pipe subways and shafts have had to be adapted to the fixed points determined by the sites and levels of the interceptors and to routes made somewhat tortuous by the present or future structures in parts of the same stratum of ground. Besides the separately obvious vertical and horizontal deflections, as shown in the sections and plan, there are combined deflections, which may be studied by comparing the plan and section at corresponding points. In Fig. 4 the section E F, Regent-street to Coventry-street, is recessed in its upper part to include a section through the London County Council subway in Shaftesbury-avenue, further details of which are shown in the section X X. Section H B shows the relative positions of the booking hall and the nearest portion of the main subway.

The high pressure or hydraulic power main, which is being kept in constant service, now passes through the Piccadilly interceptor, which is also traversed by a 12in. water supply main, to be replaced by two 18in. mains.

At the point B, shown in the plan and in section H B, there is a drainage sump, from which the water will be pumped into the sewer diversion. This part of the works area is specially interesting on account of the expedients adopted for the removal of the spoil from the Coventry-street interceptor. When our representative visited the works the spoil was being taken down a timbered shaft on the same centre line as the future permanent cast iron shaft, 12ft. in diameter, to be provided at the point F, and was taken along the pipe subway to the central shaft and there lifted out by the cranes. Before this was possible, that part of the subway not being completed, the spoil was taken through a portion of the main sewer and was passed into a cellar in the occupation of the railway company. Here it was stored until it could be removed through an excavation in Coventry-street, an unavoidable point of spoil removal, where the bell mouth of the sewer diversion will be located.

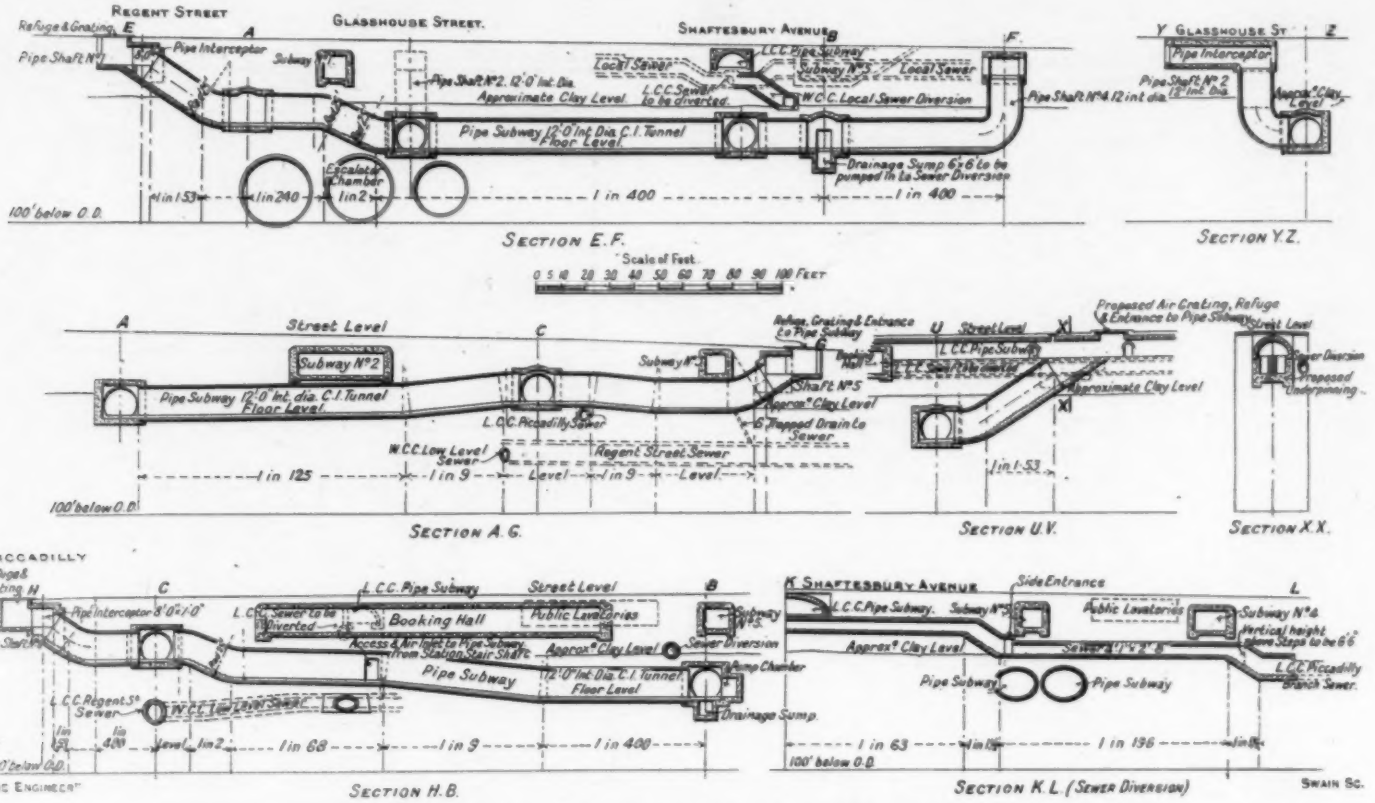


FIG. 4—ARRANGEMENT OF PIPE SUBWAYS AND CONNECTED WORKS

The Pipe Interceptors.

Each of the pipe interceptors consist of a brick chamber, the positions and dimensions being shown in the Figs. 3 and 4. On these drawings they are distinguished by the word "interceptor," the word "chamber" being reserved for the structures providing for the junctions of the several pipe subways and shafts and the larger structures at the lower ends of the excavators. Since the depths of the pipes are in some cases quite small, these interceptors have to be brought nearly up to the street level, while their small dimensions further increase the difficulty of providing the heavy timbering which would be necessary to support the concrete road crust. This difficulty has been surmounted by the expedient shown in Fig. 5, by means of which the road crust is relieved of the weight of passing vehicles. The wood block paving having been removed, rails of heavy section, 22ft. 6in. in length, were laid in a row across the interceptor—that is, lengthwise with the street. These rails are spaced 4in. apart, centres, bolted together in threes. Concrete made with rapid-hardening cement was then placed so as to fill in the spaces between the rails and to a height 1½in. above them, the concreting being continued beyond the

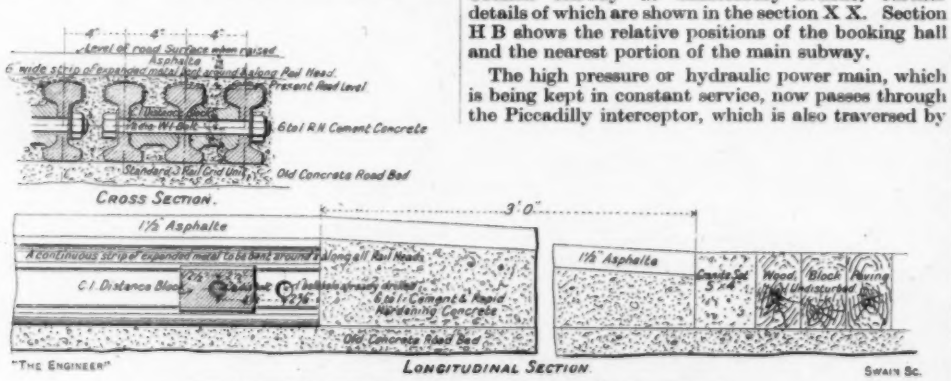

Level of road Surface when raised
Asphalte
6" wide strip of expanded metal laid around Railway Rail Head
Present Road Level
6" Thick Concrete
6 to 1 R.H. Cement Concrete
Standard 3 Rail Grid Unit
Old Concrete Road Bed
Cross Section.
3'0"
1½" Asphalte
A continuous strip of expanded metal to be bent around & along all Rail Heads
C.I. Distance Block
6 to 1 Cement & Rapid Hardening Concrete
Old Concrete Road Bed
Longitudinal Section.
"The Engineer"
Swain Sc.

FIG. 5—STREET BRIDGES OVER INTERCEPTORS, PART SECTIONS

The Sewer Diversion.

An important item of the works is the diversion of a sewer which now traverses the Circus. The new portion will be arranged, as shown in Fig. 3, between the point K in Shaftesbury-avenue and the point L opposite the Criterion, where it enters the Piccadilly branch sewer. The sewer from Glasshouse-street will join the new sewer, but the portion P Q of another local sewer will be abandoned. The section K L shows the position of the diversion in relation to passenger and pipe subways, while its present level and position at the Shaftesbury-avenue end is shown in the section U V.

(To be continued.)

The Kelvin Lecture.

On Thursday, April 21st, Professor E. W. Marchant delivered the eighteenth Kelvin Lecture before the Institution of Electrical Engineers, his subject being "High-frequency Currents." The early part of the lecture was devoted to Lord Kelvin's work in connection with the oscillatory discharge of a condenser and the applications of such a discharge. Other parts of the lecture dealt with high-frequency phenomena in dielectrics, high-frequency magnetisation, surges in electricity supply networks, and the production of electric waves. In what follows we give an abstract of the lecture.

When Faraday made his early researches on electric action, he put forward what he called the molecular theory of dielectrics. The fact that this theory was advanced nearly ninety years ago is another evidence of Faraday's genius, because, in spite of its neglect over a long period, nowadays it has come to be accepted by physicists as an accurate representation of the constitution of a dielectric. More recently the polarised particle theory of the constitution of dielectrics has been developed mathematically by Mossotti, and if considered with the modifications which are made possible in the light of modern knowledge, offers an explanation of many obscure phenomena observed in dielectrics. According to modern theory, the passage of current through a conductor is due to electrons which in a conducting metal, for example, are so loosely held that the smallest electromotive force is able to move them and so produce a current through the substance from one atom to the other. In an insulating medium such as a dielectric the electrons present in the molecules are bound. They are assumed to be arranged in the molecule in positions of stable equilibrium. When so placed they exhibit no electric polarity, but, when an electric field is applied, the positive charges are moved in one direction and the negative in the opposite direction.

The displacement of the charges in the molecule is small, since they are both controlled by similar forces to those which held them in equilibrium before the external electric force was applied. When equilibrium is attained the force due to the electric field will be just balanced by the restoring force due to the interaction between the particles. The effect of the electric field, therefore, may be regarded as producing a number of electric doublets in the medium. The behaviour of the medium can be studied on the assumption that the particles are polarised in this way when an electric field is applied to it. No material is a perfect conductor, nor is there any perfect dielectric, and therefore all materials can be regarded as being made up of a combination of the two, the actual behaviour of the substance under an electric force depending on the relative proportions of these constituents. In other words, we may say that there are present in all materials free electrons which, owing to the closeness of the molecules to each other and the large inter-molecular electric forces, acting in the inter-molecular spaces, are able to move readily from one molecule to another.

These free electrons enable the substance to conduct electricity. There are also present polarised particles which contain bound electrons and positive ions which become polarised, *i.e.*, which form electric doublets when an electric force is applied to the substance. The polarised particles in most dielectrics can be ionised and the ionisation gives rise to a current which has been called the absorption current. The production of ions in delectrics is apparent in the phenomena of frictional electricity. The rubbing together of two substances such as silk and glass brings the molecules of the two substances into sufficiently intimate contact to detach electrons from one substance, leaving it positively charged, and to give an excess of electrons to the other, leaving it negatively charged.

One can regard the polarisation of a dielectric as due to the formation of a number of polarised particles. The actual form of the polarised particle is not important, but since the specific inductive capacity of most substances is independent of the voltage stress to which they are subjected it must be assumed that the electrical moment of the polarised particle is proportional to the electric force producing the polarisation. If one takes the view that electricity is continuously distributed after the manner of a fluid and assumes that the particle consists of two spheres,* one filled with positive electricity and the other with negative electricity identical in all other respects with the first, then, if these imaginary spheres are superimposed and coincident with each other there will be an uncharged body giving no electrical effect. If one sphere is displaced in relation to the other a certain distance, the central common space will remain uncharged, but there will be on the two opposite faces positive and negative charges and an "electric doublet" is produced; a substance which behaves in this way is said to be uniformly polarised According to the modern theory of the constitution of matter, it does not seem unreasonable to assume that a polarised particle may be produced by a slight displacement of the orbits of the electrons round the nucleus of an atom in a molecule. It has also been assumed by Debye that there may be in the molecule fixed doublets formed of electrons and positive ions which remain in a molecule of constant moment and permanently electrically polarised, which can be turned under the influence of the electric field and produce effects analagous to the permanent magnetisation of magnetic substances.

The table in Jeans' "Electricity and Magnetism" shows how closely the figures calculated from Mossotti's theory agree with those found by the theory of gases. It may be suggested that the assumption of a conducting molecule is not justified in the light of modern theory. It is now known, however, that all matter has associated with it charged electric particles or electrons. In a perfect dielectric, each electron is attached to a molecule, but may vibrate within certain limits. The molecule may be regarded as consisting of a cluster of electrons normally at rest or moving in stable orbits. When an external electric force acts on the molecule the orbits are displaced and take up fresh positions. As Jeans has put it, there is a sort of tidal motion of electrons in the molecule. When the new position of equilibrium is reached, the outer surface of the molecule is equipotential, which is exactly what is required by Mossotti's hypothesis. The conception of conducting spheres, therefore, may be abandoned without impairing the theory, the surface of the spheres being replaced by shells of electrons or by rings of electrons in rapid motion, thus bringing the Mossotti theory into accordance with modern views of the structure of matter.

When a dielectric is subjected to the influence of a rapidly varying electric force, the polarisation of the particle is brought about almost instantaneously. In all theories of dielectrics it is assumed that the particles are of molecular—or perhaps a little greater than—molecular dimensions, and that, with forces of the frequencies that are used in ordinary high-frequency work, the motion is practically instantaneous. There may be a certain amount of vibration in the polarised particle and there may be a loss of energy, but the vibration will be very rapidly damped. There is, however, another phenomenon which is well known in connection with dielectrics, *i.e.*, "normal" absorption. If a steady polarising force is applied to a dielectric there will be a current passing through it which will gradually die away with time and lead to a resultant polarisation of the substance which is greater than the initial polarisation. Pellatt has assumed that the polarisation changes according to a logarithmic law. The theory of a logarithmic law of change of polarisation does not, however, fit the facts, and Schweidler assumes that there are a number of terms in the expression for polarising current corresponding with a number of damped and undamped particles of different dielectric constant and resistivity, the summation of which gives the resultant polarising current. It is evident that if a sufficient number of different terms with different constants be taken the resultant curve may be made of any desired shape. This theory, although giving a mathematical interpretation of the action of a dielectric, is not very satisfactory from the standpoint of the physicists. It seems much more reasonable to assume that the absorption current is due to ionisation and although comparatively little reference has been made to this in recent work the ionisation theory certainly deserves consideration as a means of explaining the absorption current and the dielectric power loss. Some very interesting work has been published by Gunther Schulz, who has shown that it is possible to explain the anomalous conductivity of glass at high field strengths by assuming ionisation in the solid dielectric.

One of the most interesting observations that has been made in connection with alternating currents is that the dielectric strengths of such materials as ebonite, glass and porcelain are very much less when subject to an alternating stress than when the stress is continuous. Some years ago we made some experiments in Liverpool with ebonite with a view to determining whether there was anything analogous to elastic fatigue with an insulating material like ebonite. There was little or no evidence of fatigue analogous to elastic fatigue. The dielectric strength after the material had been subject to a stress very near to its breaking stress at 50 cycles was very little less than that which was required to break down the insulation immediately after the pressure was applied. Recently Goebeler has published some figures for dielectric strength using frequencies of between 85,000 and 120,000 cycles per second, using a maximum voltage of 14 kilovolts. He has found that the breakdown strength of air between flat plates and spherical electrodes is the same as for direct current, whereas with needle points the breakdown strength is considerably lower than for 500 cycles, the difference being greater as the length of the gap increases. With glass the breakdown is only one-third of that needed at 50 cycles. With porcelain it varies from one-third to one-half, and with ebonite it is only one-half of the breakdown voltage at 50 cycles. Fibrous materials at high frequency become practically conducting. It will be shown that these phenomena may be explained by the "polarised particle" theory of dielectrics.

Let us first assume that we are dealing with the breakdown of gas under electric stress, say, in an electrodeless bulb. In a gas the molecules, which will be polarised by the electric stress that is set up in the gas, will be moving about in the bulb. If the electric force is increased the molecules become ionised by the detachment of electrons from them and subsequently by collision. When the stress on the gas exceeds a certain limit the electrons will jump from one molecule to another across the gas and cause such violent vibration of the molecules that the material will be broken down. If it be assumed that the process of ionisation occurs when the energy of a moving ion colliding with another molecule exceeds a certain value, then the law of breakdown strength of air at varying pressures is explained. With an electric force E acting on an ion or electron of mass m carrying a charge e, the velocity v given to the ion while moving over distance s is given by $v^2 = 2fs$, where $f = \frac{Ee}{m}$. The energy given to the ion is therefore $E\,e\,s$. It is independent of the mass of the ion and will be proportional to s. Now, the mean free path of a molecule in a gas is inversely proportional to its pressure. The strength of electric field necessary to develop a given amount of energy in the ion is given by $E\,s$ = constant. Hence the electric field necessary to break down the gas is inversely proportional to the mean free path of the molecules, *i.e.*, it is directly proportional to the pressure of the gas. Gunther Schulze has suggested a similar effect with liquids.

The modern theory of magnetism is based on the electric theory of matter. According to this theory, magnetic forces are produced by the motion of electric charges, that is, by the motion of electrons. There is no possible motion of an electron that can give rise to a single magnet pole, but an electron revolving in a circular orbit produces the magnetic analogue to an electric doublet, that is, a system which has north magnetism at one end and south magnetism at the other. Ampère, many years ago, built up a theory of magnetic media on the assumption that the atoms were seats of circular electric currents, and recently Mr. Evershed has developed the theory of current rings in papers with which electrical engineers are familiar. The current ring behaves like a small magnet and produces magnetic polarisation. It is evident therefore that in dealing with magnetism we are considering the action of particles of extremely small size and it is not surprising that these particles should be able to respond to the highest frequency of magnetising force t has been possible to produce. It has been shown by St. John that the magnetic permeability of iron when subjected to magnetic force with a frequency of one hundred million per second is of the same order as the permeability at lower frequencies. Many other experiments of the same kind have been made, and it is now well known that iron remains a magnetic material and can be used with suitable precautions at the highest frequency that we can produce.

The quantity which is of greatest practical importance in electrical engineering is the loss of energy that takes place when iron is subjected to alternating magnetisation. It is to be expected that the energy loss due to hysteresis per cycle of magnetisation will be somewhat less for a given magnetising force at a very high frequency. For exactly the same reason, when iron is subjected to very high frequency magnetisation forces, the permeability of the iron will be rather less than it is at the lower frequencies, although this does not become marked until frequencies in excess of 100 million per second are used. There is, however, one loss which becomes very large at high frequencies, and this is the loss due to eddy currents. At ordinary frequencies the power loss due to eddy currents in an iron wire or thin plate is proportional to the square of the frequency, but when account is taken of the smaller penetration of the magnetic flux into the iron at high frequency the power loss per cubic centimetre in iron plates of normal thickness may increase less rapidly than would be calculated from the square law. The loss for a given value of B max: is proportional to B^n, where n has a value of about 1·5 for silicon iron plates 0·25 mm. thick at frequencies of about a million. McLachlan has shown that the actual power loss in silicon iron at a frequency of one million per second is 1 kilowatt per pound with a maximum flux density of 100 lines per square centimetre. This is to be compared with the normal figure of about 1 watt per pound at a frequency of 50 cycles with a maximum flux density of 10,000 lines per square centimetre.

Some curves showing the relation between B and H for thin silicon iron plates at frequencies up to a million per second have been obtained by the cathode ray oscillograph. With the flux densities used (B = 50 lines per square centimetre approximately) the behaviour of the iron is very similar to that at lower flux densities. In interpreting the results it is difficult to separate the effects of hysteresis from those due to eddy currents and the shape of the B H loop is distorted by eddy currents. It is clearly of very great importance when using iron at high frequencies that the specific resistance of the material should be as high as possible and the use of silicon iron for high-frequency magnetisations would appear to be a practical necessity. But, not only does the specific resistance of the material affect the losses in the iron; it also changes the depth to which the magnetisation will penetrate into the substance. As a result the apparent flux densities with silicon iron and pure iron using constant magnetising force are in the ratio of about 2½ : 1, although at ordinary flux densities the permeability of pure iron is not very different from that of silicon iron. The equivalent depth of magnetisation is about three times as great for silicon iron as it is for pure iron. For a given value of the maximum flux density and frequency the larger resistance of silicon iron, however, causes a reduction in the watts lost per kilogramme. One arrives, however, at the rather surprising result that the power factor of a coil containing silicon iron working at a given magnetising force is greater for a coil containing pure iron for values of the magnetising force of the order of H = 1 — 4, and this, in spite of the fact that for given values of B max. and thickness of plate, the losses in the latter material exceed those of the former. In exceedingly thin plate in which the flux density is more or less uniform the eddy current loss will be relatively small and the energy loss in pure iron will be smaller in proportion to the magnetising current than in silicon iron. It follows from this that the advantage of silicon iron as compared with pure iron becomes less as the flux density and the frequency increase.

The variation in the electrical qualities of dielectrics at high frequencies has emphasised the need for observing the high-frequency currents and potential differences which are liable to occur in supply systems. For this purpose the cathode ray oscillograph has proved of great value, and quite recently a record of some very high-frequency currents has been obtained. Such high-frequency surges, due to arcing at switches, were discussed by the late Mr. Duddell in his address on "Pressure Rises." Such surges occur sometimes in cable systems. It is as necessary nowadays to calculate the surge impedance of a transmission line as it is to estimate its efficiency. With the increasing size of distributing high-pressure networks the possibility of the occurrence of surges due to sudden fluctuations of load at points, where the nature of transmission line changes, requires careful study. Steep-fronted waves of high frequency along a transmission line may produce a dangerous rise of pressure

* This view of electricity is inadmissible as a working theory, as it has been shown by Earnshaw that doublets of this kind cannot exist in Nature.

at a point where the transmission system changes from overhead line to underground cable. The chief danger of such high-pressure surges is the risk of their breaking down the insulations of the cable dielectrics, but in certain cases there is an almost equally great danger due to the mechanical forces which come into play when high-frequency currents flow. One of the risks that is involved by the increased size of power stations is the large store of electrodynamic energy in the distributing system. As Lord Kelvin pointed out, when an electrical oscillation takes place, the energy is transformed from electrodynamic to electrostatic and *vice versâ*. With the increasing size of power stations the currents that will flow when a short circuit occurs are enormous, and it follows therefore that the voltage that is produced when a free oscillation takes place will also be relatively high. Quite recently F. Rutgers† has described experiments showing the generation of high-frequency oscillations due to short circuits between the turns of a transformer or the break in an overhead line. These oscillations were detected by means of apparatus branched off one of the leads to the detective gear. The apparatus employed for detection was a crystal detector and telephone or a valve receiver combined with recording apparatus. It is interesting to observe how closely the weak current and heavy current engineer are linked to each other, and the advantage which the heavy current engineer can obtain by a knowledge of some of the phenomena of high-frequency currents.

The lightning flash, which is the oldest electrical phenomenon with which the world is familiar, is, of course, a high-frequency discharge. It may be of interest to give a quotation from Lord Kelvin's 1853 paper. He says :—"It is probable that many remarkable phenomena that have been observed in connection with electrical discharges are due to the oscillatory character which we have thus found them to possess when certain conditions are fulfilled. Speaking of lightning, he says :—"If the interval between the successive instants when the strength of the current is a maximum is sufficiently great and the evolution of heat in any part of the circuit by the current is sufficientlyintense to produce a visible light, a succession of flashes diminishing in intensity and following one another rapidly at equal intervals will be seen. It appears to me that double, triple, and quadruple flashes of lightning which I have frequently seen on the Continent of Europe and sometimes, though not so frequently in this country, generally lasting long enough to allow an observer to turn his head round and see distinctly the course of the lightning in the sky, result from the discharge possessing this oscillatory character. A corresponding phenomenon might probably be produced artificially on a small scale by discharging a Leyden phial across a very small space of air." These words do not sound antiquated to-day.

Some interesting experiments have recently been made in the laboratories of the General Electric Company in America by K. M. McEachron and E. Y. Wade on transients similar to those which occur when lightning arresters flash over. By use of a Dufour oscillograph they have been able to obtain photographic records of transients lasting only a few millionths of a second and have been able to determine the time of operation of needle points.

The chief reason why high-frequency currents have become so much more important, practically within the last few years, is, of course, due to the fact they are used nowadays so universally for the production of electric waves. The technique of high-frequency currents is now better known—I will not say more clearly understood—than Ohm's law, and all this has come about within the lifetime of many of us. Broadcasting has made everyone familiar with the essential features of an oscillatory circuit. Not only has the increase in the production and detection of long and short electric waves taught us a great deal about the transmitting qualities of the atmosphere to these waves and the behaviour of the earth's surface when subjected to high-frequency alternating currents, but it has enabled us to gain a much greater knowledge of the nature of the upper atmospheres. The experiments recently described by Appleton have enabled us to realise quite clearly how the state of ionisation in the upper regions of the atmosphere varies from hour to hour. The layer of ionised air which is generally known as the Heaviside layer reflects the high-frequency waves which come against it. By changing the wave length of the transmitting station it has been possible to estimate the rise in height of the layer when the sun sets and the fall in height when the sun rises. As time goes on there will no doubt be other observations of a similar kind. I have described a mere fraction of the applications that have arisen as the result of the start which was given to the study of high-frequency currents by Lord Kelvin's 1853 paper, and although one must be careful not to over-emphasise the value of one single contribution to the development of so large a branch of applied science, I think it may justly be said that, had it not been for this classical paper, a great deal of the progress that has been made within the last seventy years would have been impossible.

† "Observations of Disturbances, such as Short Circuits, by High-frequency Effects," F. Rutgers. Scheweiz Electro Verein, Bull, 16 pp., 389–400, July, 1925.

The Vacuum Brake in India.

(By an Indian Railway Engineer.)

The article entitled "The Battle of the Brakes," which appeared in The Engineer of November 22nd, 1889, was indeed prophetic; its premonitions have matured into facts almost to the letter. India adopted the vacuum brake on claimed merits which were very inadequately tested, and now, after equipping all the stock—goods and passenger—at a cost of some £6,000,000 sterling, it is found that difficulty is experienced in getting the brake to work satisfactorily on the long goods trains which traffic development has called into existence; exactly the trouble anticipated in the article referred to.

The equipment of the goods trains of the broad-gauge railways has now been in hand for a number of years; in fact, it is quite twenty since the Government of India made the recommendation that goods as well as passenger trains should be fitted, although no definite instructions were issued as to the procedure to be adopted—a very serious neglect on the part of the Railway Department.

All new wagons (broad gauge) put into service since 1904–5 have been furnished by the manufacturers with complete brake apparatus, and, when turned into traffic from the Indian workshops after assembling, had the gear put into working order. Owing, however, to the fact that the existing stock was not "piped" or fitted and only a limited number of the locomotives had the necessary ejectors, &c., the brake apparatus of the new vehicles was not worked, with the result that it became corroded, defective and useless; the rubber details invarably becoming unserviceable.

During the war period the phenomenal increase of traffic brought pressure upon the limited rolling stock, and foremost among the railways to make efforts to get the brake apparatus in order was the Great Indian Peninsula, owing to the necessity for power brakes when operating heavy trains down the Ghaut gradients into Bombay. Perusal of the "Proceedings" of the L.C. and W. Superintendent's Committee of the I.R.C.A. shows how persistently the matter has been debated; some railways pressing for immediate action, whilst others appear to hold back. Why? it is difficult to understand, unless it is that doubts exist as to the possibility of ever being able to work the vacuum brake satisfactorily on the very long goods trains. Resolution followed resolution, and eventually the I.R.C.A. recommended that the Railway Board should definitely fix a date for the brakes to be put into full operation. This date was to be April 1st, 1924, but was afterwards extended to April 1st, 1925, and then again, as a last concession, August 31st, 1925, was given at the meeting of the I.R.C.A., held in Simla, during October, 1924. A resolution was, however, passed at the L.C. and W. Superintendent's Committee in February, 1925, requesting the I.R.C.A. again to approach the Railway Board and prolong the period for two years—until March 1st, 1927. The President of the I.R.C.A., on being invited to support this recommendation, consulted the agents of the chief broad-gauge lines and pointed out the inadvisability of any such procedure, and advised ratifying the decision that the brakes must be in working order as from September 30th, 1925, the owning railway being charged for re-conditioning of any vehicle which should be offered at an interchange station with brakes in bad order. After further delay the date was fixed for the 1st of this month, and it is to be hoped that all railways will now cheerfully co-operate to have brakes in full working order on all trains, for until that is *un fait accompli* none of the benefits expected to accrue can possibly be realised.

First, as a safety appliance. The full effect under this head can only be secured when all the trains are equipped and working. If the brake pipe is attached throughout a train and the rear vehicles are provided with automatic brake apparatus, in case of break-aways or mishaps, the continuous brake will be applied on both portions of the train, which will thus be brought to rest in safety.

A second advantage anticipated is the speeding-up in operation of trains and the better utilisation of the wagon stock. This has been fully demonstrated on the G.I.P. Railway, in the large reduction of working hours secured by trains proceeding intact over the heavy gradients already mentioned. There has been a considerable decrease in shunting hours also at the depôt stations of the different divisions, as also in the goods trains miles, owing to the reduction in the number of trains running. The total saving is estimated at over 11½ lakhs of rupees per annum, which, capitalised at 6 per cent., will produce an income of nearly 2 lakhs (£14,000)—not an insignificant advantage.

It is claimed that in America and Canada, where all trains are operated with continuous brakes, considerable saving in operation expenses is secured, and it is hardly conceivable that the American railways are presided over by such unbusinesslike men as would enthusiastically provide continuous brakes on goods trains for nothing more gratifying than seeing them work.

The third advantage is that some direct return should be assured for the capital already spent in equipping the stock. At the present time heavy goods trains in India usually have two weighted vehicles in the shape of "brake vans," taring 20 tons each, attached in the rear; total 40 tons, consisting mainly of cast iron blocks, which are hauled over long sections of railway simply to enable sufficient brake power to be available in case of break-aways, &c., on gradients. When the continuous brakes are in operation throughout a train and all vehicles are fitted with brake apparatus, it is obvious that any rupture of the train pipe will automatically "set the brakes," and stop both portions of the train. Hence these two brake vans could be replaced by two wagons carrying remunerative loads, with a light rear van for the guard to travel in; this last might also be utilised for goods-carrying purposes. When this is done a credit will be obtained against the debit of increased tare caused by the addition of the continuous brake apparatus to the wagons. Equipping the 140,000 broad-gauge goods vehicles of the Indian railways with brake apparatus adds, approximately, 100,000 tons to the dead weight of the rolling stock hauled, and it is very desirable that some attempt should be made to secure an off-setting benefit.

There is one feature connected with this problem of equipping goods trains with continuous brakes which is worth mentioning. It is the small amount of brake power obtainable *pro rata* in the ordinary manner. With passenger trains the difference between the empty tare and the loaded gross weight of the carriage is so small that it need not be considered; it is customary to provide brake power on these up to 80 or 90 per cent. of the empty tare. The same proceeding is adopted with regard to goods vehicles, but it must be remembered that the tare of these vehicles in India is generally less than half the load they carry. An Indian standard broad-gauge wagon, weighing 10 tons, will carry 22 tons, and, braked up to, say, 80 per cent. of its tare weight, gives an efficiency of 8 tons. There is this amount of power only available when the vehicle is fully loaded and weighing 32 tons, hence the brake power on a loaded goods train, equipped in the ordinary manner, is much less than that which is provided for on a passenger train. To make the comparison more unfavourable, the goods train often has but 12in. of vacuum against 20in. to 22in. for the passenger.

Attempts have been made to overcome the difficulty with the vacuum apparatus by providing vehicles with a combined arrangement—that is, one cylinder providing the brake power for the empty vehicle and another—a larger one—to provide for its loaded condition. The arrangement applied to some of the G.I.P.R. vehicles was illustrated in our issue of August 24th, 1923. With the air brake, additional power is often provided over certain sections by simply increasing the working pressure, *e.g.*, over a level section a train pipe pressure of 70 lb. is maintained, whilst over steep gradients the apparatus can be charged to 90 lb. As a typical example of what may be expected from air brake service over severe mountain gradients with heavy loads we quote the following :—

"On the 10,730 miles of track of the Pacific system of the Southern Pacific Railroad, U.S.A., no accident to any train—passenger or goods—resulted from the loss of control through brake failure during two years, covering a mileage of about 75,000,000 train miles."

For one year the property damage charged to air brakes amounted to 160 dollars, although the train mileage was over 34,500,000, the failures of air brake to train mileage being as 1 in 1,234,000, or fifty times round the earth at the equator. It may be also mentioned that on this system no hand brakes are used to control the speed of trains, and on the 3·3 per cent. gradients over the Siskiyou Mountains the safe load permitted for every standard air-braked car is 45 tons. Goods trains over this section are hauled by four locomotives of the 2–10–2 class, each having a tractive force of 75,100 lb. The maximum load hauled is 2400 tons.

With examples like these from the operation of heavy trains it is difficult to comprehend the hesitation experienced in India to have the vacuum brake in full working order, so as to reap the advantage from the capital sunk and save the haulage of so much extra deadweight represented by the brake gear under wagons in service.

Operating the train brakes by vacuum instead of plenum prevents the use of many power appliances on the rolling stock of Indian railways which rely on compressed air for manipulation, such as the reversing gear, sanding of rails, fitment of boosters, &c., to locomotives, control of auto-cars, operation of doors, water supply to lavatories of carriages, and many other incidentals applicable to railways, steam and electric, particularly attractive in a tropical country. It might be remarked further that it would be absolutely impossible to control the heavy trains running on the American railways with vacuum brakes. Our "cousins" had sufficient foresight to recognise the limitations of the system before traffic development rendered such brakes impracticable.

A new company has been registered in South Africa, with a capital of £17,500, for the exploitation of some large manganese deposits in the Kuruman district.

Hard-drawn Copper Conductors.

(By a Correspondent.)

DESPITE much that has been said and written concerning the advantages to be claimed by various alternative materials, pure hard-drawn copper still holds supremacy for use on overhead transmission lines. The low resistivity gained from the minimum of sectional area, and the comparatively high ultimate tensile strength, are the controlling factors in the choice of this material, and the fact that it has been chosen almost universally since the inception of overhead power transmission, cannot fail to give an engineer a large measure of confidence in the physical properties which it possesses, and in its power to resist the depreciation of those properties by ageing or by atmospheric attack. A point that is often overlooked when selecting the most suitable material for use on overhead lines is that of fatigue. It must be understood that all those alloys of copper which are made to have a comparatively small conductivity loss with a large gain in tensile strength obtain the latter by reason of the fact that the alloy, under work, hardens up more quickly than does the pure metal. For example, were a rod of bronze annealed under exactly the same conditions as a rod of copper, the tensile strength of the two rods would be approximately equal; after equally reducing the diameters of these rods by drawing, it will be found that the bronze has a very much higher tensile strength than the copper wire. Advantage is taken of this phenomenon to produce wires having tensile strengths up to 45 tons per square inch, as compared with 30 obtained on pure copper. But, in positions where the line is subject to excessive flexure, it is reasonable to assume that the bronze wire fatigues more quickly than the copper, and fails owing to what is usually, although erroneously, termed "crystallisation."

As cast, electrolytically refined copper has nothing but its high conductivity to commend it. The large crystal size, with consequent small area of crystal boundary, results in great mechanical weakness. The tensile strength at this stage is but 6 to 8 tons per square inch—varying, of course, with the casting conditions. But immediately work on the bar begins, the breaking up of the original structure hardens the material, and it is found that a hot-rolled rod has an ultimate stress of 16 tons per square inch. Such hardness, however, is not altogether irremovable; annealing of the rod would reduce the strength to 14 tons per square inch. This figure is a minimum covering the whole range of annealed copper. It would appear that it is coincident with a definite limitation of the re-orientation of the crystals during growth under the heat treatment. With cold drawing, individual crystals suffer elongation, with a consequent reduction of area. This process has the effect of increasing the tensile strength of the resultant wire, and it is found that the hardness, as so measured, is a linear function of the diameter. This fact would tend to support the hypothesis that the effect of drawing is purely "skin effect"—as the hardness varies with d and not with d^2—whereas microscopical examination shows the cross section to be a homogeneous whole. If it be considered, however, that the hardness is due to skin effect, but that this effect is of sufficient depth to penetrate to the centre of the wire, then there is no inconsistency in the hypothesis. Indeed, this is borne out by several investigators who have claimed that on a small hard-drawn wire the centre is slightly harder than the outer fibres, which fact could be explained in that the successively deeper layers of skin effect impressed upon successively smaller wires has produced, as it were, double work at the centre of the wire.

The classical papers of Pye—*Journ.*, Inst. Met., 1911, Vol. II.—and Alkins—*ibid.*, 1918, Vol. II.—have done much to elucidate the phenomena observed during progressive cold work on pure copper. The principal of the first degree linear expression suggested by Trotter and examined in Pye's paper, was the first attempt to correlate definitely observations made in the laboratory. Later, Alkins attempted to disprove the value of such an expression by showing that, at a point where a reduction has been carried out to the extent of 50 per cent. of the original area, an arrest occurs in the increase of hardness. As regards the building up of a specification to cover the supplies of material, however, a simple straight-line curve appears to be of great value. It must be noted that manufacturers are not tied down to produce wire from any definite size of rod, and therefore Alkins' observations, designed to show the history of a complete series of sizes drawn from one size of rolled and annealed rod, hardly cover the point.

In the British Standard specification 125, covering hard-drawn copper wire for transmission line purposes, a table was included showing the minimum tensile strength of any single wire. These values, when analysed, prove to be very closely a first degree function of diameter; more accurately, two expressions cover the whole range of sizes from 0·064in. to 0·400in. diameter. The first covers sizes up to and including 0·215in. diameter, and is expressed as—

$$T = 31 \cdot 305 - 23 \cdot 756\ D,$$

and the second—

$$T = 30 \cdot 916 - 20 \cdot 782\ D,$$

for wires above 0·215in. diameter. T is the tensile strength in tons per square inch, D being the diameter in inches. These expressions prove of value when it is desired to interpolate a size not actually covered by the specification.

The resistivity of pure annealed copper wire has been laid down by the International Electro-technical Commission to be 0·017241 ohms, with a wire 1 m. long and uniform area of 1 square millimetre, at a temperature of 20 deg. Cent. This, with a specific gravity defined at 8·89, gives a mass resistivity of 0·15328 ohms per metre-gramme at 20 deg. Cent. The "constant mass" temperature coefficient is stated to be 0·00393 per degree Centigrade. These values have been adopted as standard by all those countries represented on the Commission, and are the basic values for the resistivity figures in our own British standard Specifications for annealed copper wire. The resistivity of a hard wire is increased as a result of the alteration in structure effected by working. This increase obviously depends on the amount of work impressed on the wire, and a simple expression correlating the two values is included in B.S.S. 125. It is that $P = \frac{T}{10}$, P being the actual percentage increase over the resistance of soft wire, T being the stress in tons per square inch. Thus, for a wire of 28·3 tons per square inch, the resistance is 2·83 per cent. higher than that of a soft wire having the same diameter.

The elastic limit in hard-drawn copper wire occurs at a point when the stress is at about 70 per cent. of the ultimate stress, and the modulus of elasticity is in the region of 18×10^6 lb. per square inch. Both these values vary slightly with the hardness of the wire, but not to a very large extent.

The process of stranding hard wires reduces the tensile strength of the individual wire by an amount which varies with the wire size and number of wires in the strand. This reduction is caused partly by the "nicking" of one wire by another, and partly by the bending and pulling of the wire in the stranding machine. The whole loss may be taken as 10 per cent., a complete conductor having 90 per cent. of the total tensile strengths of the individual component wires. This point is more fully dealt with in B.S.S. 125, where also particulars are given of the tensile strengths of the constituent wires after de-stranding. The value of the British standard specification for this material is evident when one realises that it has brought order in place of the chaos which formerly existed when the number of specifications was legion.

The Safety of Horizontal Milling Machines.

WE have received the following communication from the Home Office, under the date April 22nd, 1927:—

GENTLEMEN,—I am directed by the Secretary of State to say that his attention has been drawn to the risk of accident incurred by persons employed in factories on horizontal milling machines, and the need for taking special steps to insure that adequate precautions are observed. The accidents reported to the factory inspectors show that the use of these machines is attended with considerable danger—an analysis of the reports in 1921 showed that in that year 378 accidents had been caused by milling machines, mostly of the horizontal type; and it is important therefore, particularly as a large number of young persons are employed on these machines and as the number of machines in use has increased of late, that all reasonable steps should be taken to safeguard the workers. Many employers have already provided their horizontal machines with guards (of which various good makes are now on the market), but this is by no means always done, and accidents due to neglect to take proper precautions are still of frequent occurrence.

Sec. 10 of the Factory and Workshop Act, 1901, contains provisions in regard to the fencing of all dangerous parts of machinery, and till recently, these provisions were regarded as requiring the fencing of the cutters of horizontal milling machines and were applied accordingly by the factory inspectors. It would now appear, however, from a recent decision of the Court of Session in Scotland that the provisions of that section are not sufficient to insure that the cutters are provided with proper guards. Moreover, the section does not in any case impose any obligation on the part of the workers to use and maintain the guards in proper adjustment.

Further, the Secretary of State is advised that as part of the cutting surface must necessarily be exposed for the milling operation, other precautions besides the provisions of a guard are required. An efficient starting and stopping appliance should be provided, and special care should be taken to see that the lighting is good and properly arranged, and that the floors are not slippery or rendered unsafe by loose material. Accidents from slipping on to the exposed cutters have occurred to persons other than those actually working the machines.

In these circumstances the Secretary of State has certified horizontal milling machines to be dangerous, and he proposes, as has been done in the case of other kinds of dangerous machinery such as self-acting mules, wood-working machines, &c., to supplement the general law by Regulations sufficient to meet the necessities of the case. The enclosed draft has been prepared for this purpose.

The Secretary of State accordingly gives the following notice in pursuance of Sec. 80 of the Factory and Workshop Act, 1901:—

> That he proposes to make Regulations, in accordance with the enclosed draft, for any factory or part thereof in which a horizontal milling machine is used; and that copies of the draft may be obtained on application to the Factory Department, Home Office, London, S.W. 1; and that any objection with respect to the draft Regulations by or on behalf of any person affected thereby must be sent to the Secretary of State within forty days of this date. Every such objection must be in writing and must state:—(*a*) The draft Regulations or portions of draft Regulations objected to; (*b*) the specific grounds of objection; and (*c*) the omissions, additions, or modifications asked for.
>
> I am, Gentlemen,
> Your obedient Servant.
> MALCOLM DELEVINGNE.

Draft.

STATUTORY RULES AND ORDERS, 1927, No. ——.

FACTORY AND WORKSHOP.

DANGEROUS AND UNHEALTHY INDUSTRIES.

The Horizontal Milling Machines Regulations, 1927, *dated* ——, 1927, *made by the Secretary of State under Sec.* 79 *of the Factory and Workshop Act*, 1901 (1 *Edw.* 7, c. 22).

In pursuance of Sec. 79 of the Factory and Workshop Act, 1901, I hereby make the following Regulations and direct that they shall apply to any factory or part thereof in which a horizontal milling machine is used.

Provided that if the Chief Inspector of Factories is satisfied in respect of any class of horizontal milling machine or of any class of milling cutter used on such machines that, owing to the special conditions of work or otherwise, any of the requirements of the Regulations can be suspended or relaxed without danger to the persons employed, he may by certificate in writing authorise such suspension or relaxation for such period and under such conditions as he may think fit. Any such certificate may be revoked by the Chief Inspector at any time.

These Regulations may be cited as the Horizontal Milling Machines Regulations, 1927, and shall come into force on ——, 1927.

Duties.—It shall be the duty of the occupier to observe Part I. of these Regulations.

It shall be the duty of every person employed to observe Part II. of these Regulations.

Part I.: Duties of Occupiers.—1. The floor surrounding every horizontal milling machine shall be maintained in good and level condition and kept free from loose material, and effective measures shall be taken to prevent it becoming slippery by the splashing of suds or otherwise.

2. Effective measures shall be taken for securing and maintaining sufficient and suitable lighting at each horizontal milling machine, and where artificial light is provided the lighting points shall be so placed or shaded as to prevent direct rays of light from impinging on the eyes of the operator while he is operating the machine.

3. The cutter of every horizontal milling machine shall be covered by a strong and readily adjustable guard, which shall enclose the whole cutting surface except such part as is necessarily exposed for the milling operation. The guard shall be provided with a side flange which shall extend beyond the root of the teeth of the cutter.

4. Every horizontal milling machine shall be provided with an efficient starting and stopping appliance and the control of this appliance shall be in such a position as to be readily and conveniently operated by the person operating the machine.

5. When suds or other cutting lubricants are used on a horizontal milling machine adequate provision shall be made to enable the operator to spply the suds or lubricant or to adjust the supply pipe without risk, and suitable and safe means shall be provided for removing the swarf.

6. The guards or other appliances required by these Regulations shall be maintained in an efficient state and shall be constantly kept in position while the milling cutter is in motion.

Part II: Duties of Persons Employed.—7. Every person employed on a horizontal milling machine shall use and maintain in proper adjustment the guards or appliances provided in accordance with these Regulations.

SIXTY YEARS AGO.

THE problem of disposing of or utilising in some way our immense fleet of old wooden line-of-battleships, provided a subject for hot debate sixty years ago. Structurally most of them were sound in spite of the fact that they ranged in age up to forty or fifty years. Many of them had been built for steam propulsion and others had been converted from sail to steam. There was a considerable volume of opinion in the country in favour of cutting down the best of the old craft and rebuilding them with armour protection in which form, it was contended, they would yet prove a match for the newer ironclad vessels. From time to time our own columns contained particulars of proposed schemes for rehabilitating the old wooden walls in modern guise, and, on the whole, we were in favour of the procedure. The Lords of the Admiralty, however, saw otherwise. They believed in scrapping the old fleet on the most advantageous terms obtainable and building a fresh one in accordance with the latest advances in naval architecture. Our issue of April 26th, 1867, contained particulars of a recent sale of ten wooden ships by the Admiralty to the shipbreakers, and a strong criticism of the terms that had been secured. The vessels sold were the Colossus, Collingwood, Orion, Cressy, Imperieuse, Euryalus, Termagant, Arrogant, Chesapeak and London. They ranged in length from 190ft. to 240ft., and carried from 25 to 91 guns. They had been built between the years 1841 and 1855, and had been equipped with engines, either originally or subsequently, of from 300 to 600 horse-power. For this fleet the Admiralty obtained from the shipbreakers a total sum of £68,000. The outcome of the sale was applauded in Parliament and the general Press, but we found nothing in it for applause. The British oak of which the vessels were constructed would, we stated, have fetched 4s. per cubic foot and would by itself have paid for the cost of breaking up the vessels had the Admiralty undertaken the work itself. Each vessel on the average was estimated to contain 1654 tons of timber, 120 tons of iron, 40 tons of copper bolts, 14½ tons of copper sheets, 8½ tons of lead, and 4½ tons of rivets, pintles, &c. The copper, iron and lead of the ten vessels would, we held, have realised about £108,000, and the engines and boilers at £4 per horse-power, the regular market value, a sum of at least £18,520. The Admiralty, we contended, might have realised over £126,000 from the old ships instead of £68,0000, and had virtually thrown away about £58,000. The entire proceeding, we thought, deserved a parliamentary investigation. It was rumoured, we added, that the sale had been effected not by the proper department but by officials within whose province the duty did not fall.

ROYAL SOCIETY OF ARTS: COMPETITION OF INDUSTRIAL DESIGNS, 1927.—By permission of the Board of Governors of the Imperial Institute, this year's competition will be held in the Indian Pavilion of the Imperial Institute, South Kensington, S.W. Full particulars of the scholarships and prizes offered in connection with the competition can be obtained from the Secretary of the Royal Society of Arts, Adelphi, W.C. 2. Applications for forms of entry, labels, and instructions must be sent to the Secretary of the Society between May 2nd and May 13th. The designs entered for the competition are to be forwarded to the Imperial Institute between June 20th and June 22nd, and after the judging, which takes place in July, the accepted designs will be on view there during the whole of August (Sundays included).

Paint-making Machinery.

No. IV.*

The material delivered by the triple-roller grinding mill is really a paste, not paint in the ordinary sense of the word, and it requires thinning and refining before it is ready for use. There is a variety of different methods of carrying out the process, depending on the ultimate product aimed at; but it will be necessary only to describe a few typical machines to give an impression of the general procedure.

The first operation is to add to the paste sufficient thinning liquid, such as oil and turpentine, to bring it to the proper consistency and thoroughly to mix the whole together. Mixing machines differ much in their design, but almost all are alike in that the spindle of the stirrers is vertical, so that material may be introduced into the top of an open receptacle, which is used to convey the paint from the grinding mill to the mixer. Opinion seems to differ as to whether it is better to lift the filled receptacle or pan up to the machine, to immerse the mixer in the paint, or to lower the mixer into the paint, but the result is, obviously, much the same.

A mixer of the latter class is illustrated in Fig. 16, which represents a machine by Torrance and Sons, of Bitton. As will be gathered from the engraving, the mixing is effected by a double action—the rotation of two sets of mixing blades and the rotation of the pan itself. The pan is set upon a turntable, which is provided with a large bevel gear rim that meshes with another bevel wheel on the driving shaft. The two sets of stirring blades are mounted on spindles in a head which can be slid up and down the column of the machine by means of the screw and hand gear shown. When the head is dropped to its lowest position against a stop, the bevel wheel on the inside set of stirrers meshes with the main driving bevel and, in turn, transmits a drive to the other stirrers through a pair of gear wheels housed inside the head.

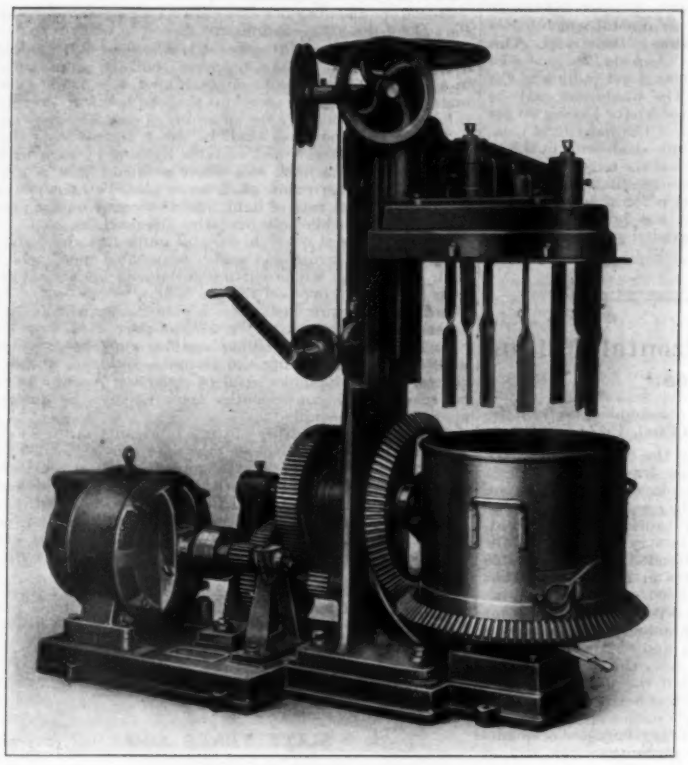


FIG. 16—PAINT MIXER—TORRANCE

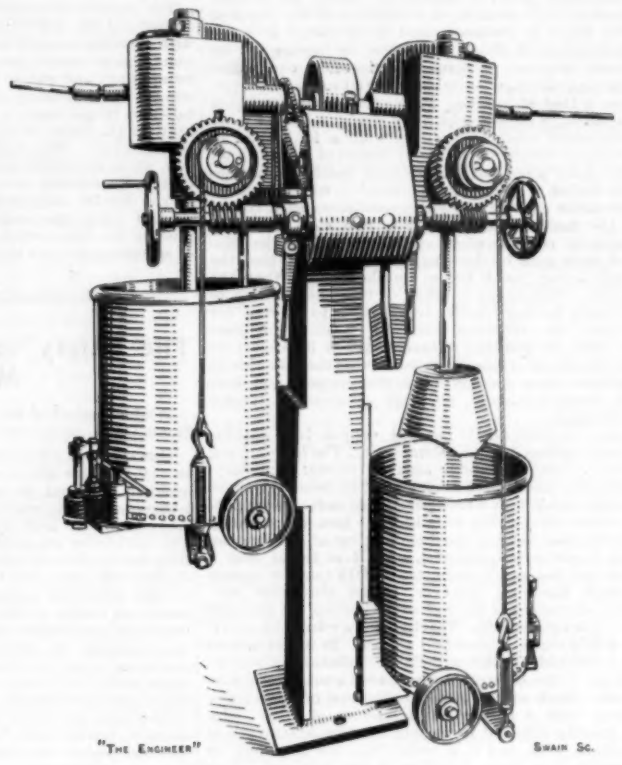


FIG. 17—PAINT MIXER—MARCHANT

When the paint has been thoroughly mixed, which requires very little time, as will be readily understood from the thoroughness of its agitation, two alternatives are available. The pan of mixed paint may be taken away bodily, and another one put in its place, when the mixing head is raised into the position shown in Fig. 16. Alternatively, the paint may be drawn off on the spot. In this case the pan is stopped, by means of a clutch lever, with the outlet in a convenient position, but the stirrers are left in engagement with the driving gear, so that the paint is constantly agitated and the contents are withdrawn with a uniform consistency from first to last. The pan shown in the illustration is some 30in. in diameter and runs at the moderate speed of about 25 revolutions per minute.

A typical example of a mixing machine in which the pan is raised to meet the mixer is illustrated in Fig. 17, which represents a double-headed machine by Marchant Brothers, of London. The lifting gear for the pans, it will be seen, comprises a pair of platforms, on to which the pans are trundled. These platforms are guided up the central column and are raised by means of wire ropes and little winch barrels. The winches can be driven by worm gear connected with the main driving shaft by means of a chain. In order to avoid complication in the gearing, by providing a reverse for lowering the pans, simple dog clutches are arranged between each of the worms and its driving shaft. When the clutch is opened, the pan is still safely suspended, as the worm will not reverse, but it requires hardly any effort on the part of the attendant by turning the hand wheel seen on the end of the worm spindle to lower the pan.

The mixer itself takes the form of a hollow cone, fixed on the bottom end of a long spindle by means of arms in the form of propeller blades. These blades are so set that they cause a rapid circulation of the paint down inside the cone and up the sides of the pan. There is a fixed baffle, which can be seen alongside the column in Fig. 17, which prevents the formation of a vortex. The mixing action is very rapid and effective, and does not tend to produce air bubbles in the paint. The pans of the machine illustrated are 21in. in diameter by 24in. deep.

For some purposes paint as it leaves the mixer is sufficiently refined for service if it is merely strained to eliminate any accidental impurities, such as pieces of string or oil seeds. On the other hand, for really fine work the paint must be passed through a finishing mill.

For direct straining, such a machine as that shown in Fig. 20 is employed. It is a very simple piece of apparatus, and works on the principle of the centrifugal separator. The paint is fed from the overhead

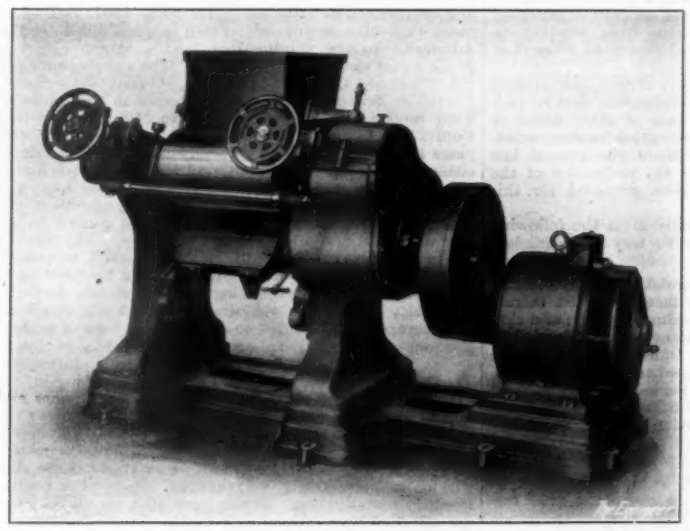


FIG. 18—FINISHING MILL—TORRANCE

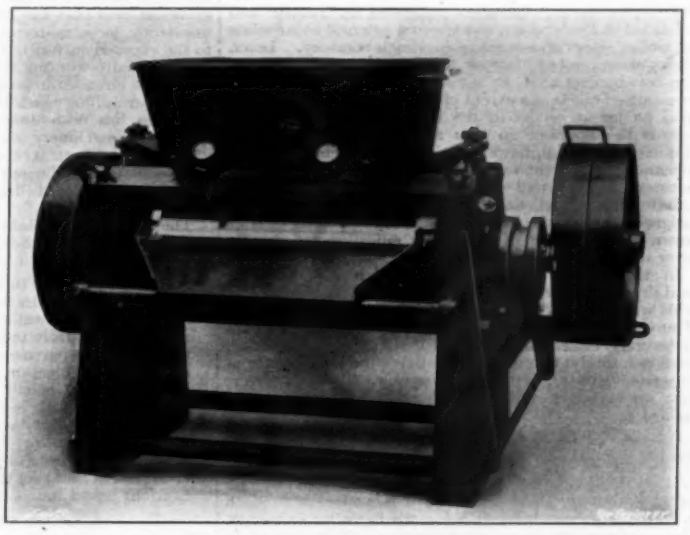


FIG 19—SINGLE-ROLL FINISHING MILL—SIDNEY SMITH AND BLYTH

* No. III. appeared April 22nd.

tank into a basket of woven bronze wire, which is driven at a speed of some 300 revolutions per minute, through machine-cut bevel gearing. The wire basket is slipped inside another basket of perforated sheet metal, which is fixed on the driving shaft, and the connection between the two is made by means of buttons, so that the wire basket can be easily removed. For some classes of paint, silk bags are used inside the basket to produce a very fine mesh.

As the straining proceeds the inside of the basket tends to become clogged up, and if the attendant were inattentive there might be risk of the raw paint overflowing over the top of the basket and contaminating the strained paint. The contingency is, however, overcome by providing a flange-like lip at the top of the basket which extends into an annular channel at the top of the container. Any overflow is caught in this channel, and is drained away by a spout at the back. It is then only necessary to stop the machine, take out the dirty basket and slip in a clean one, to go on with the straining.

The basket of the machine illustrated is 11½in. in diameter by 14in. deep, and is made of from 40 to 180 mesh gauze, according to the class of paint required.

When it is desired to impart a very good finish to paint or enamel, it is necessary to re-grind it after the mixing process, and there are several styles of mill for the purpose. That shown in Fig. 18, which is by Torrance and Sons, is known as the "Micro-Twin," and is chiefly peculiar on account of the high ratio of speed between the rolls. Only two rolls are used,

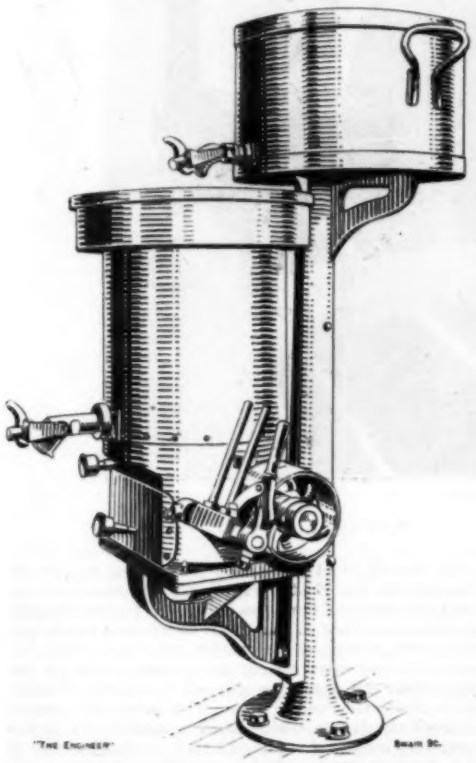


FIG. 20—PAINT STRAINER—MARCHANT

and they are both glass hard. They are driven by machine-cut gearing, and have a speed ratio of about 20 to 1. The adjustment is of the micrometer type, similar to that described in connection with the Torrance triple-roller mill. Between the two rolls there is arranged a hopper, for the reception of the mixed paint, which is fitted very carefully to the curvature of the rolls. The upper surfaces of the rolls consequently form the bottom of the hopper, and the slow-running roll forms what might be described as a live breast, which carries the paint forward to the grinding contact with the fast-running roll. At the same time the charge of paint in the hopper is constantly stirred up, so that it is kept of equal consistency throughout the length of the run. As a consequence, any foreign matter which may find its way into the paint is kept in suspension and is retained in the hopper until all the liquid paint has passed through the rolls, so that it may be cleaned out at the end of the run. During its passage between the rolls the paint is subjected to a very powerful grinding action, which disintegrates every particle and brings the product to a uniform fineness, and it is then scraped off the roll to run down a covered tray into tins or cans, as may be required. The breast roll is, of course, provided with a lateral motion, similar to that already described, to prevent flats wearing on its face, while water cooling is employed to keep the rolls from getting too hot. The output of these mills naturally varies with the nature of the paint being refined, but that illustrated is capable of delivering at least from 30 to 50 gallons per hour. Its hopper has a capacity of 15 gallons.

Another form of refining mill has already been described in THE ENGINEER—in connection with our articles on linoleum machinery—but it seems appropriate to reintroduce it here, with the idea of making this review complete within itself. This machine, which is illustrated by Fig. 19, is by Sidney Smith and Blyth, of 35, Garratt-lane, Wandsworth, and is noteworthy on account of the fact that it has only a single roll. The paint is ground between this roll and a fixed longitudinal bar. The roll is, of course, very hard, and is ground to a smooth surface. In the case illustrated it is 15in. in diameter by 30in. long, and is driven through gearing at a speed of about 120 revolutions per minute. At one end of its spindle there is keyed a scroll-shaped cam, which engages with a fixed roller and gives the main roll a slight endways movement, that is accommodated in the length of the teeth of the driving gears, and ensures that the roll and bar wear evenly. Across the front of the machine there is fixed a stiff girder in which the grinding bar is fixed. The bar is of cast iron and about ⅛in. wide at the working edge. This edge is ground hollow to fit the curvature of the roll. The bar is held in place by the thumb screws and springs seen in the illustration, and is adjusted for clearance from the roll, according to the quality of paint required, by the screws with knurled heads. The hopper for holding the stock of paint is made a very nice fit on the roll, and against the bar, and can be adjusted in place by means of the micrometer screws that can be seen over the tops of the end frames.

It might be thought, in view of the narrow face presented to the roll by the bar, that it would wear away rapidly, and also that the paint would quickly pass under it without much refining, but, as a matter of fact, the reverse is the case. The bars have a very long life, and not only is the paint ground very fine, but all impurities, such as fibres and grit, are also prevented from passing the bar and are retained in the hopper. The hopper is, of course, cleaned out after the day's run, and the care bestowed on this job affects the life of the machine as much as anything else. If, after cleaning out, the bar is carelessly put down again with a piece of grit beneath it, the bar and roll will be quickly scored. The output of these mills naturally varies with the class of paint being made, but ranges in the case of the size illustrated from 120 to 200 gallons a day of eight hours.

(To be continued.)

Helium in Canada.

FROM 1922 to 1926 the Mines Branch of the Dominion Department of Mines, as part of a survey of the natural gas resources of Canada, made a special study of the helium content of the gases, and a thorough examination was made of all possible sources of that element. Ten years ago helium was considered a rare substance, occupying, as regards its rarity and value, much the same position among gases that radium holds among metals.

Following the discovery by two American chemists that some natural gases contained helium in small amount, and the suggestion by a British scientist that it might be commercially possible to obtain helium from such natural gas in sufficient quantity to fill balloons and airships for war-time use, extensive investigations, commenced in 1917, were carried out in the United States, and on a smaller scale in Canada. As a result, up to the end of 1926, over twenty-five million cubic feet of helium had been obtained by the United States Government, and the cost of production reduced to a basis that will permit of commercial utilisation. Helium was also extracted in small amount in the experimental plant at Calgary, operated under the direction of Professor J. C. McLennan, F.R.S., of the University of Toronto, in 1919–1920, for the British Admiralty.

Helium possesses many remarkable properties which may make it a very valuable industrial gas. It is an ideal gas for filling balloons and airships, for although it has 10 per cent. less buoyancy than hydrogen, it has the great advantage of being non-inflammable. An application of helium that promises to become of great value is its use in making up artificial atmospheres to supply to divers and workers under pressure. An investigation, still in progress, by the United States Bureau of Mines, has shown that there are great possibilities along these lines, and that such artificial oxygen-helium "airs" may permit of greater depths being attained and longer periods being spent under water by divers, and the prevention of caisson disease among tunnel and caisson workers. Suggestions for other industrial uses have been put forward, but outside of the United States no commercial supplies have yet been available.

In the survey of helium resources in Canada made by the Mines Branch it was found that the gas from three small wells at Inglewood, Ontario, contained as high a percentage of helium as that treated in the United States Government plant at Fort Worth, Texas. The Ontario Government has since taken up many of the leases in that neighbourhood, and it is anticipated that the National Research Council may establish an experimental helium extraction plant, if it be proved that sufficient gas is available. A few wells in other fields in Ontario, particularly in Norfolk county, yield gas carrying 0·5 per cent. helium. Natural gas in Alberta, where much larger quantities are available than in Ontario, was found to contain little or no helium, with the exception of that from the Bow Island and Foremost Fields. If natural gas, containing as little as 0·2 per cent. helium, could be economically treated to extract helium, it is calculated that about five million cubic feet could be obtained in Canada annually.

The results of this investigation are described in a report "Helium in Canada," by Dr. R. T. Elworthy, recently issued by the Mines Branch, which contains a brief account of the particulars and occurrences of helium, the methods employed in the work, and some account of the methods of recovery of helium and its uses.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

INTERNAL COMBUSTION LOCOMOTIVES.

SIR,—In your leading article in THE ENGINEER of the 15th inst. you made special reference to remarks of mine during the discussion on Colonel Kitson Clark's paper recently read before the Institution of Mechanical Engineers on the Kitson-Still locomotive.

May I be allowed to say in defence of my attitude that, in my opinion, any impartial person reading the article of March 4th to which I referred would stand excused if he understood that it was intended to refer principally to the locomotive engineers of this country and only incidentally to the railway managements.

The steam locomotive of to-day, while it may only be an enlargement and rearrangement of the earliest forms, is a vastly different machine from its old forbears. In weight, power, efficiency, reliability, convenience of maintenance and working, capacity for service, and grace, the British steam locomotive stands to-day a fitting monument to all the illustrious names of the past and present locomotive engineers of this and other countries.

All this, Sir, has been accomplished while the railways have been run to schedule, and amidst all the internal changes always going on, including at last the tremendous upheaval brought about by the grouping of the railways.

No one knows better than our present locomotive engineers the shortcomings in efficiency, &c., of the existing machine, and they are always on the look-out for, and are quick to avail themselves of, any and every suggestion for improvement which appears in the least promising. All our railways possess a section devoted to the conduct and investigation of experiments made at no small cost to the companies in order to keep abreast of the times.

Our locomotive engineers are approached and consulted for opinions on the many proposals for improvement always being placed before the railway managements, while contractors avail themselves of opportunities always gladly afforded to discuss their projects with the heads of our railways.

As to the suggestion that our boards of management being men of little vision who will not incur the expense of experiments, that is hardly true or fair comment, for the reverse is generally the case. There is, however, one reason, I suggest, for their seeming lack of progress which is not far to seek, and that is the financial position of our railways. Nevertheless, no promising proposal is turned down before the opinion of those capable of judging the case on its merits has been sought and obtained.

The article, however, while it was careful to mention many of the items—some of which, by the way, are still in the experimental stage—possessing foreign names or origin, failed to refer to very many improvements in the locomotive which have originated in this country, and are used successfully all over the world; while, in addition, it can be said that the "Paget" engine on the late Midland Railway, the "Decapod" on the late Great Eastern Railway, the three-cylinder compound on the late North-Eastern Railway, and the "Garratt" type engine have all witnessed to the desire and endeavour of our British locomotive engineers and railway managements to solve the railway locomotive problem.

The locomotive contract builders in this country have always found the railways ready to assist them in the trials of their projects, and in support one might refer to the Reid-Ramsay turbine locomotive, the Reid-Macleod turbine locomotive, the Ljungstrom turbine locomotive, and later we shall hear, no doubt, of the trials of the Kitson-Still locomotive on an English railway.

As regards consideration of the internal combustion locomotive, it is hardly correct to say that no British railway has yet tried one on its lines, for the old North-Eastern Railway actually had one running some years ago on its system for trial.

Now I think, Sir, that I have said enough to make good my reasons for having commented seriously on the article in question, and in conclusion would record my admiration for the way in which THE ENGINEER has championed for many years the cause of our revered and trusty friend the steam locomotive.

JAMES CLAYTON.

Chief Mechanical Engineer's Office,
Waterloo Station, April 26th.

THE OLDEST ENGINEERING FIRM.

SIR,—I noticed that in your issue of March 18th you printed a short note saying that the question had arisen as to which engineering firm had been longest established at one address. You stated that Rose, Downs and Thompson, Ltd., had been at the Old Foundry, Hull, for no less than 150 years, and that Richard Garrett and Sons, Ltd., were established at Leiston only one year later—in 1778.

As this is a matter in which I am particularly interested, I shall be glad to hear whether you have received information regarding firms which may have been working at still earlier periods, and are still working on the original site.

April 25th. CLYDESIDE.

[So far, we have received no replies to the note to which our correspondent refers. We shall be glad, however, to hear from any firms which have longer continuous histories of operation at one place than either of the two firms mentioned.—ED. THE E.]

AN OLD BEAM ENGINE.

SIR,—May I suggest that it would greatly add to the interest of such a letter as that of Mr. Yates in your current issue—"Old Beam Engine on G. J. Canal"—if he had added (*a*) approximate steam cut-off, (*b*) approximate vacuum. As it stands it is not possible to calculate the mechanical efficiency, which is quite an interesting point in connection with these old machines.

GEO. T. PARDOE.

Angmering, April 25th.

[With reference to the foregoing letter we have received the following information from Mr. Yates:—(*a*) The approximate steam cut off was at half stroke. This used to be altered slightly according to which reservoir was being pumped. (*b*) The vacuum was about 23in. as a rule.—ED. THE E.]

POPLAR ELECTRIC GENERATING STATION

FIG. 1—16,000-KILOWATT TURBO-GENERATOR

A New Power Station at Poplar.

On Monday, April 25th, the official opening took place of a new electric generating station in the borough of Poplar, where, in consequence of the development campaign initiated by the Borough Electrical Engineer, Mr. J. H. Bowden, the demand for electricity is rapidly increasing. Recognising that the old and original station could not meet future requirements, the Electricity Committee instructed Mr. Bowden to report on the question of constructing a new and more modern station, and after inspecting stations on the Continent and in the United States, Mr. Bowden prepared a scheme of electric power generation involving the use of pulverised coal and larger generating units than those hitherto adopted by the borough of Poplar Electricity Department. At present the combined capacity of the two stations is 26,000 kilowatts, the new station containing at the moment a single unit with a capacity of 10,000 kilowatts—see Fig. 1. Access to the new station, which is situated in close proximity to the old one in Glaucus-street, can be obtained by canal and roadway, so that in addition to the provision of a supply of water for condensing purposes, water-borne coal is available. The site chosen had to be levelled, and in order to make the canal wall safe for bringing barges alongside, it was necessary entirely to reconstruct the whole of the canal frontage.

The design of the building was worked out in accordance with the regulations of the London County Council by International Combustion, Ltd., whilst the contract for the work was entrusted to the Mitchell Conveyor and Transporter Company, which also prepared the foundations for the outside cranes and chimney, and carried out the excavation work in connection with the laying of the circulating water pipes and the interconnecting cable trenches. The layout of the building was arranged on the assumption that the whole of the coal supply will be water borne, and on the western side of the station there is a space for raw coal storage. On the wharf there are two cranes, one steam-operated and the other electrically-operated, both provided with a grab for unloading from barges and delivering to the hopper for storage at the coal pile, or to the hopper feeding the plant. After passing a Simon or, alternatively, a motor-driven Avery scale and a magnetic separator, the coal is conveyed by the elevator and conveyor system to the two main coal bunkers, one having a capacity of 100 tons and the other 200 tons. A gravity bucket elevator supplied by the Mitchell Conveyor and Transporter Company lifts the coal through a vertical distance of 70ft. and discharges it into the raw coal bunkers.

Provided that no sacrifice in efficiency or too great a disparity in cost occurred, the Committee and Engineer decided that as far as possible orders should be placed with local firms, and the pulveriser house therefore contains, in addition to plant supplied by International Combustion, Ltd., plant made by the East Ferry Road Engineering Company. There are two complete sections of coal treatment, one working on the Raymond system, which, of course, is adopted by the former firm, and the other operating on the Bradley system, which is employed by the latter firm. There are two Raymond mills, each capable of dealing with 12,000 lb. of coal per hour. The dryers for these mills are of the rotary steam-heated type, in which air is employed to carry off vapour formed in the process of drying. The Raymond pulverising mills, Lopulco dryers and exhausters, the feeder gallery and the boiler-house are illustrated on page 470. The dryers for the Raymond mills are of the rotary steam-heated type, in which air is employed to carry off vapour formed in the process of drying. Each of the Raymond mills is capable of pulverising the coal at the rate of 12,000 lb. per hour and so that 85 per cent. of the ground product passes through 100-mesh screens and all through 40-mesh screens, the pulverisation being effected by rollers running in a circular track in the well-known manner.

Each mill has an exhauster fan with an air ducting system, by means of which the mixture of pulverised coal and air is conveyed to the cyclone separators, where separation is effected by centrifugal action and by gravity, the pulverised fuel falling to the bottom of the cyclone and thence to the pulverised fuel screw conveyor, whilst the air is returned to the system. With a view to preventing the building up of a pressure in the system, an atmospheric vent pipe is provided in the return air pipe just after it leaves the cyclone. The return pipe is also connected with the dryer, so that any coal carried in suspension past the cyclone may be deposited in the dryer before the excess air is discharged to atmosphere.

In the case of the Bradley pulverising equipment supplied by the East Ferry Road Engineering Company, the raw coal from the bunkers is passed through an automatic feed to the dryer, which is of the rotary type with a vertical series of trays, over which the coal is distributed during its passage through the dryer, and the drying is effected by means of waste gases from the boiler flue. The gases are passed through the dryer—which has a capacity of 4 tons per hour—by means of a fan and they escape by way of the chimney stack. Before entering the dryer the gases are cooled sufficiently to prevent ignition of the coal, and an auxiliary inlet is provided on the dryer to prevent re-condensation of the moisture driven off by the coal. The dried coal then passes to the mill, which is of the three-roll type and is capable of pulverising 3½ tons of coal per hour, so that 65–75 per cent. passes a 200-mesh sieve and 95 per cent. a 100-mesh sieve. By means of a short screw conveyor the pulverised coal is then passed through a dust separator to a cross screw conveyor having a capacity of 10 tons per hour, that discharges into the vertical bucket elevator, which delivers the coal to the main powdered coal screw conveyor, which, in turn, carries the pulverised coal to three storage bins situated over each boiler.

In view of the fact that the details of the Lopulco system of pulverised coal firing are well known, it is scarcely necessary to describe the coal feeders and burners, and we will pass on to the general boiler-room equipment. At present there are three steam-raising units, which were supplied by the Vickers Boiler Company. Each is designed for a normal evaporation of 50,000 lb. per hour and has an overload evaporative capacity of 70,000 lb. per hour. The working pressure is 325 lb. per square inch and the final temperature of the steam is 700–714 deg. Fah. The boilers were constructed in the maker's works at Barrow-in-Furness. Two are of the standard cross-drum steel-cased type, whilst the third is of the Vickers patented double-circulation type, the heating surface in each case being 6200 square feet. Feed water is supplied to the boilers through a Foster economiser supplied by the Power Specialities Company, Ltd., each economiser having a heating surface of 2196 sq. ft., and being designed to raise the temperature of the feed water to 240 deg. Fah., thereby reducing the flue gas temperature to about 540 deg.

Fah. To attain the final steam temperature each boiler is fitted with a Ferguson superheater with a heating surface of 3950 square feet. Before its entry to the combustion chamber the air is heated by an "Usco" plate-type air heater manufactured by the Underfeed Stoker Company, Ltd. Each of these heaters has a heating surface of 6950 square feet and under normal conditions will raise the temperature of the air from 60 deg. Fah. to 260 deg. Fah. and reduce the flue gas temperature from 540 deg. Fah. to 340 deg. Fah.

The combustion chambers are designed in accordance with the standard "Lopulco" practice, and are provided with the usual water screen and water-cooled rear wall elements. Each furnace is provided with a water screen across the bottom of the combustion chamber. Its main function is to create a relatively cool zone at the bottom of the chamber, through which the molten ash passes and solidifies into a finely divided state before reaching the ash hopper, thus enabling the boilers to be operated with the minimum excess of air, at all ratings up to the maximum rating, without slag formation. To promote rapid circulation in the water screen and rear wall tubes, connections are taken direct from the boiler drum to the bottom screen header and the top header of the rear wall. While serving primarily to protect the brickwork, the water cooled rear walls form with the water screen a useful addition to the boiler heating surface and materially increase the evaporative capacity of the plant.

Air for combustion is supplied by a forced draught fan capable of delivering 30,000 cubic feet of air per minute, at normal temperature, against a static head of about 1in. water gauge, whilst the products of combustion, after passing through the economiser and preheater, are discharged by the induced draught fan into a flue which is common to all three boilers and is connected to a steel chimney outside the boiler-house. The fans were supplied by Musgrave and Co., Ltd., whilst the chimney is of the Thompson self-supporting type. For general use in the station, a compressed system has been provided. The compressor is of the Sentinel motor-driven type, manufactured by Alley and MacLellan, Ltd.

Ash gates and chutes are provided at the bottom of each combustion chamber to enable the ashes to be discharged into a water-sluicing trough in the basement floor. The ashes are carried to an ashpit outside the boiler-house, where they are handled by a grab crane and loaded into wagons. In front of each boiler is mounted an instrument panel, as shown in Fig. 6 on page 470. Provision is made for measuring and recording the temperatures and quantities of steam and feed water and also the air and flue gas temperatures, whilst in the turbine room there is a master panel for recording total steam and feed quantities. The instruments were supplied by Electroflo Meters Company, Ltd. On the master panel there is a multi-point temperature recorder for observing air and flue gas conditions at any one of the boilers, this equipment having been supplied by the Cambridge Instrument Company.

The turbine room has been designed to accommodate two generating sets, but up to the present only one machine has been installed. The set, which is shown in Fig. 1, is designed for an output of 12,500 kilovolt-ampères when working at a pressure of 6600 volts, and it was supplied by the General Electric Company. The Fraser and Chalmers turbine runs at a speed of 3000 revolutions per minute and is capable of developing 25 per cent. overload. Steam is supplied to the machine at a pressure of 300 lb. per square inch and a total temperature of 700 deg. Fah., the specified vacuum being 28in. The condensing plant, which is of the Contraflo type, was supplied by Vickers Ltd.

The main 6600-volt switchgear in the station consists of six electrically-operated oil circuit breakers of the metal-clad type with duplicate bus-bars made by the Metropolitan-Vickers Electrical Company. One of these breakers serves for the 12,500 kilovolt-ampère alternator, two for controlling the feeders connecting the old and new stations, two for the step-down transformers which supply the station auxiliaries and one for connecting the duplicate bus-bars. Remote electrical operation of the circuit breakers is effected by means of solenoids energised by push buttons and contactors which are mounted on a vertical control board to be seen in the foreground of Fig. 2. The switchboard to be seen in the background of this illustration is a low-tension board supplied by George Ellison for the control of supplies for the auxiliaries and for lighting; in other words, it is a house service switchboard. Two transformers were supplied by the Metropolitan-Vickers Electrical Company, each capable of dealing with the total auxiliary load at a pressure of 450 volts. Each has a capacity of 750 kilovolt-ampères at a power factor of 0·8, when working from the high-tension supply. In order to facilitate their removal from a raised plinth to the workshop for repairs or cleaning, they have been erected outside the station and they are consequently of the outdoor type.

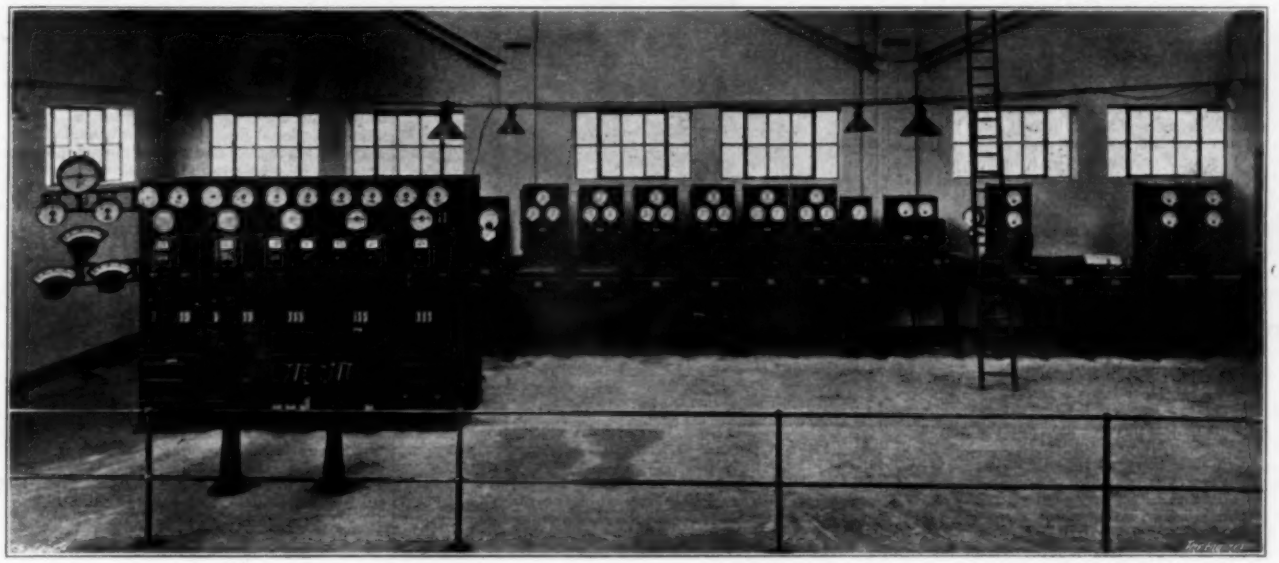


FIG. 2—MAIN CONTROL PANELS AND HOUSE SERVICE SWITCHBOARD

New Work Always Ready for the Men who Do Things.

By FRANK RICHARDS, Plainfields, U.S.A.

THE profession of engineering is pre-eminently and uniquely the one which confidently makes its promises and then completely fulfils them. It does not *try* to do, but it does; and of none of the other professions can this be said. The clergymen, the physicians, the lawyers work as hard in their several ways, with a skill as deserving of respect, and they fairly earn their honours; but the results of their labours can none of them be characterised as certain and enduring and precisely predictable beforehand, and, in general, they do not even permit of any precise measurement or comparison. Some of them can be called either a success or a failure according to the view point.

Engineering failures are in these days practically unknown, and history can tell only of achievements. What the engineer plans and undertakes is certain of successful completion, so far as the doing of it is entirely in his own hands, and the world has the confirmed habit of trusting him implicitly, notwithstanding that the tasks he undertakes are continually growing in magnitude, requiring the satisfying of conditions more exacting and often of some hitherto unheard of. The East River bridges of the City of Bridges were regarded for more than a generation as practically the limit for the suspension type of bridge, or, indeed, close to the limit for a bridge of any possible design, and even the slight extension of the suspension limit by a paltry 50 yards in the Philadelphia Bridge was made a world-wide boast of engineering daring; but there was never the slightest doubt or question as to its completion in full perfection, although its dimensions and capacities exceeded the traditional limit.

But perhaps one of the most astounding demands ever made upon the engineer is that to which he now responds. Not by successive enticing little increments, as heretofore in bridge building, but by a single leap of the constructive imagination confirmed by deliberate engineering determination, the epochal span of the Philadelphia Bridge is to be all at once doubled! That has a clear span of 1750ft., lacking only 10ft. of one-third of a mile, and now we are to have the New York–New Jersey bridge over the Hudson of exactly double this span—3500ft., or very close to two-thirds of a mile. The marvel of the age is perhaps no greater in the engineer's undertaking of this stupendous task than in the unhesitating confidence of the civilised world in its complete fulfilment. The engineer says that he can and will build that bridge, and all are sure that it will be done. And so it goes. Whatever may be demanded, when we have the engineer's responsible assurance, there is nothing more to be said, and there are no lurking uncertainties.

Whatever the engineer may successively accomplish beyond anything he has already achieved, the latest is never the last, and greater wonders are still to be wrought, exceeding in some particular all that have yet gone upon the record. Just now we are getting our first look through the Moffat Tunnel, but there are at least two greater tunnels already planned—the Lochaber Tunnel in Scotland, 18ft. in diameter and 15 miles long, and a vehicular and railway tunnel, 32 miles long, through the Cascade Range. And now, the New York–New Jersey bridge being off our minds as a thing most sure of accomplishment, we cannot help but look ahead a little farther to see a still greater bridge; only a little greater perhaps in structure, but almost incomparably greater in possibilities of service and most imperatively demanded.

Staten Island is New York's white elephant. It is the one persistent disappointment in the natural growth and development of the great city, and all because of the lack of free and sufficient facilities of traffic common to all the other boroughs. A bridge across the Narrows is the one thing needed most of all to make New York complete, and all its boroughs in free communication with all the rest, especially by automobile and motor truck. With the New York–New Jersey bridge, now a certainty, it is impossible not to be considering the possibility, the practicability, the ultimate certainty of this bridge, even though it must be a greater bridge than any which the world's engineers have yet been challenged to plan and construct.

And not so much greater, either. The length of the Hudson River bridge, 3500ft. for the central span with 1750ft. for the approaches, equalling 7000ft., would be sufficient to reach across the Narrows, or, since the theoretical limit for a suspension span, as determined by the tensile strength of the cables and related considerations, is said to be about 6000ft., we might assume a central span limit of 4000ft., with a total reach of 8000ft., which would liberally satisfy the requirements.

But while the length of the bridge in the case of the crossing of the Hudson at the point selected was the only particular demanding the serious consideration of the engineers, the bridging of the Narrows involves other stupendous difficulties which the engineers have first to face and to determine the possibility of their solution. The location for the former bridge is practically an ideal one. Solid rock easily accessible is waiting for the erection of the main piers and the anchorages, and it is certain from the beginning that no novel or difficult problems of construction are involved. At the Narrows there is deep tide water with uncertain material underlying, so that the operations required would be beyond the reach of the familiar pneumatic caisson methods, and how the foundations for the piers could surely be built no man seems to know. So here it is up to the men who do things to settle it whether this great thing can or cannot be done, and if it can be done, they must show us certainly the how of it. It would be a waste of time to be thinking any farther along this line until this is settled, so that all waits for the engineer.

The present writing is little more than an irresponsible suggestion of the writer, and is not backed by any abounding personal conviction, but if it can be shown that the bridge can be built, it becomes at once imperative to prepare in fullest detail the plans for the building of it. The usual sequence of procedure will not suffice in this case. The bridge must be entirely built and finished on paper, and then the building of it in stone and steel will be assured—except for the one greatest obstacle of all.

It is not for us to belittle the function or to question the wisdom of the official guardians of not only the present, but also of the prospective far future of perhaps the greatest of the two or three great shipping ports of the world. The Port Authority and the United States engineers may, if they so determine, absolutely and most properly bar the building of the bridge as in some way an interference with or an obstruction of the free movement of

craft of any description having business in or out of the port. Although to the layman, all military or naval objections to the building of the bridge may not be obvious, it is not for us to argue them.

It is a curious thing, however, that the building of a great thoroughfare bridge at the Narrows, putting the island into intimate, living, pulsating connection with the city as a whole, would inevitably lead to a great modification and extension of the shipping facilities of the port, and certainly it would be for the Port Authority to begin to consider this as an item of its legitimate business. More than 10 miles of the most valuable and important portion of the city's water front, the entire eastern shore of Staten Island, has never been utilised because the island as a whole has lacked vital connection and free and ample communication with the heart and life of the city. Here is the normal and obvious location for the piers of the great Transatlantic liners, where the passage of the Narrows and the tortuous channels of the upper or inner bay would all be avoided, and the facility of movement for all craft would be distinctly promoted.

But the allusion above is merely incidental. The story of the development, or rather of the non-development, and of the present status of the borough of Richmond, which is Staten Island, is the great argument for the bridge. The entire area of the island, it is to be remembered, is as desirable for residence, for industry of every type, as that of any of the boroughs, with a score of miles of the most desirable water front for shipping. Here 20 per cent. of the total land area of Greater New York has a little over 2¼ per cent.—·0228—of the total population, with less than 4—3·65—persons to the acre, while the number to the acre for the whole city, with this borough included, is 32·6. The Narrows bridge would immediately begin to change these figures.

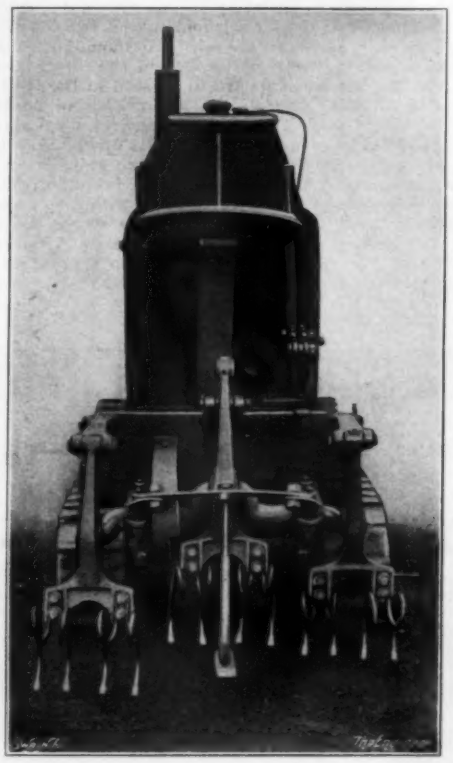
But the Staten Island Bridge would be much more than that. It would be a national institution. It would fill the now only existing gap and would complete the great north and south-east coast highway, making an uninterrupted thoroughfare from New York, indeed from Canada, to Florida and serve all the northern and western States of the Union. It would necessarily be a bridge of great capacity, and if later a second bridge were demanded that need not trouble us. It may well be that for a fourth time within one hundred years New York will build the biggest bridge in the world—each a monumental success of the men who do things.

Mechanical Tea Garden Cultivator.

ANYONE who has lived in the East will admit that the problem of cultivating the surface soil of a tea plantation by mechanical means would be rather difficult of solution on account of the natural habit of the plants or bushes. They resemble to some extent a currant bush, and are planted in close rows, so that there is practically no open space between the branches of the adjacent rows of bushes. It is, nevertheless, necessary to cultivate the intervening soil in order to encourage the growth of the bushes and to keep down the growth of weeds. This cultivation is usually done by hand labour, which is both expensive and tedious; but there has recently been developed a machine—illustrated in the accompanying engravings—that appears to have prospects of completely supplanting hand work. It is made by Wm. Foster and Co., Ltd., of Lincoln, and we recently saw it in operation on a piece of rough land in London.

It will be readily understood that one of the first requirements of such a machine is that it should cultivate the soil as closely as possible to the stems of the bushes without damaging the overhanging branches, while its weight should consolidate the ground to the least possible extent. The first requirement has been met by providing a low-built, wide, cultivating gear, while the second is satisfied by arranging all the machinery in a narrow casing which will brush past the bushes without breaking the branches. The whole machine is carried on two caterpillar tracks, which distribute the weight of the machine over the ground, so that the pressure at any one place is no greater than that of an average man's foot. All these features are well illustrated in the accompanying engravings.

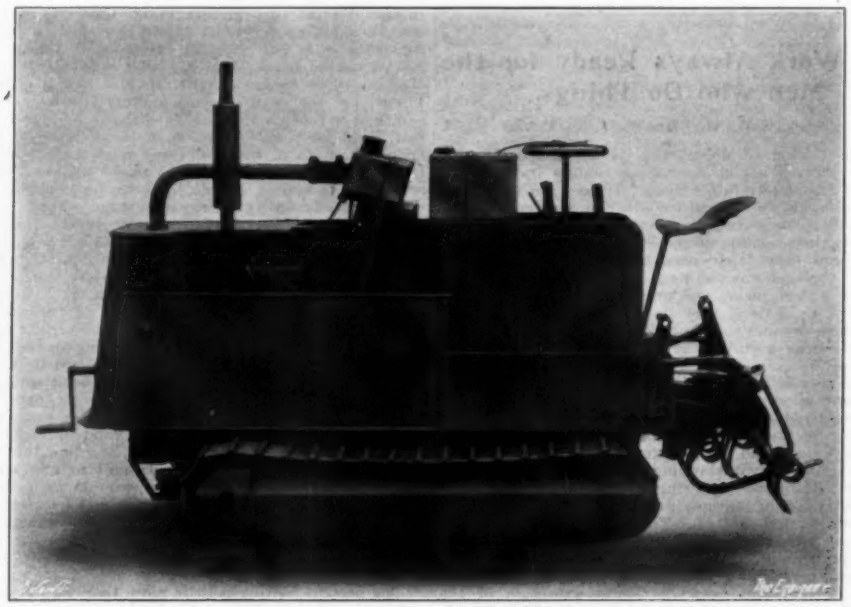
The actual digging is effected by means of twelve steel tines, arranged in three groups of four, made of spring steel. The tines are attached to the bottom ends of forked rocking levers, which are connected by links at their upper ends with fixed cranks. About the centre of the length of the rocking levers there are journals for the crank pins of a transverse shaft, which is driven by the engine. The whole gear is mounted in a frame pivoted to the machine, so that the depth of cultivation can be adjusted. An



REAR VIEW OF CULTIVATOR SHOWING TINES

adjustable skid running on the surface of the ground, which can be seen in the centre of the machine, in the rear view, determines the depth of digging. The resultant effect of the rotating crank shaft and the linkage is to give the tines an elliptical movement which thoroughly scarifies the soil and throws it backwards, so that the tines do not become clogged with weeds. For normal working the depth dug is usually 3in., but it may be increased to 4½in. if necessary.

The same engine drives both the cultivators and the creeper tracks. It is a 16 horse-power Dorman engine, having four cylinders, 69 mm. by 100 mm., and runs at a



TEA GARDEN CULTIVATOR

speed of 1550 revolutions per minute. The radiator, which is of large capacity on account of the hot climate of the tea plantations, is behind the engine, and is cooled by a draught provided by a positively-driven Blackman fan. An air filter is fitted to the induction pipe of the engine.

The power is transmitted from the engine through a plate clutch to a gear-box with a transverse shaft, on which there are sprockets for chains to drive the creeper tracks. The final drive to the tracks is through epicyclic gears, which are connected with the steering wheel in such a manner that either track can be driven or checked. In this way the machine can be steered with great nicety, and can be turned round in its own length. This gear is very similar to that installed on the military tanks. The driving gear for the cultivators comprises an extension of the propeller shaft, which drives a worm and worm wheel through a dog clutch. The worm wheel is keyed on to a transverse shaft, which acts as the pivot for the cultivator frame, and has a sprocket for the chain that drives the crank shaft. All the gearing runs in ball bearings and the chains are enclosed by oil baths.

The tracks are 4ft. 7in. long, and on them there run twelve supporting wheels, so that field drains, 18in. wide, can be crossed without crushing in the sides. The loading on the ground is about 3 lb. per square inch. The speed is 1½ mile per hour, and the width cultivated is 2ft. 5in. The width over the body of the machine is only 16in. while the height of the tracks is 12in. The total length of the machine is 7ft., and its weight is 13 cwt.

During the trials which we witnessed the machine was run over a piece of waste land which was overgrown with weeds. It stirred up this ground very effectively, leaving a nice fine tilth and rooting up all the weeds, while an occasional brickbat caused no harm. The machine appeared to be very handy, and could be steered with exactitude, while it made practically no impression on a fairly soft wet soil. On a made road the marks it made, even when turning on its own axis, were almost imperceptible.

American Engineering News.

Track Brakes for Gravity Yards.

A notable development in goods yard shunting on American railways is the rapidly increasing use of car-retarders or track brakes to control the movements of the wagons when operated by gravity. The retarders consist of sectional flexible rails or beams which are parallel with the track rails and can be moved inward at regulated pressure, so as to grip the passing wheels. Both the brakes and the switches of the several yard tracks are operated by a few men in elevated cabins, each man having a list showing on which track each wagon is to be set. By means of a teletype instrument these lists are written simultaneously and automatically in the towers as the main list is being typewritten in the yard office. This arrangement of control dispenses with the men who ordinarily ride each car to control it by the hand brakes, work which is dangerous, especially in winter, and which involves the expense of keeping one line of rails open for an engine or motor car to bring the men back to the hump on which the wagons are started by gravity. The towermen also control devices for placing sliding skates on the rails when necessary to check a wagon which has passed the brakes. At the Blue Island yard of the Illinois Central Railroad there are five towers controlling fifty-one retarders or track brakes and twenty-nine points. In three successive eight-hour shifts 1766 wagons have been classified and 1190 cars have been classified in one eight-hour shift.

Permanent Way Recording Car.

In a new track recorder car built recently for the Santa Fé Railway System, U.S.A., six classes of information are recorded by stylus pens on a travelling roll of paper ruled with longitudinal lines which form the base lines of the records as charted by the pens. The information includes the following:—(1) Low rail joints; (2) gauge; (3) lateral swing of bogie and car body; (4) cross level of track and inclination of car body; (5) time intervals to determine speed; (6) mile posts, bridges, stations and other landmarks. The first five are recorded automatically, four by movements of the mechanism and the time by a clock connection. The sixth is operated by a push button by an observer. For low joints, the two outer axles of a six-wheel bogie are rigidly connected by a frame, while the middle axle has vertical play in relation to this frame. For gauge, two 6in. wheels are held against the rails by a spring mechanism, any movement of which is transmitted to the recording pen. This mechanism also serves to operate the pen which indicates lateral motion. For the cross level record a gyroscope, placed in a vertical plane longitudinal with the car, is used. The rotors revolve in this plane at 12,000 revolutions per minute, one running clockwise and the other counter-clockwise. An air balancing device at 8 lb. pressure restrains the movement of the gyroscope and returns it to normal position when it has been disturbed by some external force. This is the first track recorder car to employ the gyroscope in the United States. The paper or chart moves at a uniform speed of 13·2in. per mile travelled by the car, and each 33ft. rail length is represented by ¼in. on the chart.

Pipe Lines for Oil.

With the extensive exploitation and development of oil and natural gas fields in Texas and Oklahoma, there has been great activity in the construction of pipe lines 50 to 250 miles in length, conveying the oil or gas from the wells to gathering stations and to the distant refineries. Modern practice in this work differs considerably from that of earlier pipe line construction. Instead of large gangs of men digging the trenches and laying the pipe there is extensive use of excavating machines, back fillers and tractors. Welded joints on the pipes are also replacing the threaded sleeve joints, which are screwed up by machines travelling along the pipe. Portable acetylene generators mounted on trucks are hauled by tractors. At first, speed and cheapness were the main considerations, but now the making of "100 per cent. welds" is insisted upon, and is much more economical in spite of the increased first cost. There has been some doubt also as to the successful welding of pipes more than 10in. or 12in. in diameter, but some of the important oil companies are using that process on pipe lines of 16in. and 20in. diameter. Successful results depend evidently upon the quality of the work rather than the size of pipe. To prevent restriction of flow of heavy oil by internal fins or protrusions caused in welding, scrapers are sent through the pipe. Tests by vacuum are made to detect leaks, and cold-water pressure tests are made, sometimes at 850 lb.

Railway Matters.

THE Baltimore and Ohio Railroad is painting its locomotives an olive green, striped with red and gold. The engines are also to be named, and the first locomotives so treated will be named after the first twenty Presidents of the United States.

THE new train and steamship service from the London, Midland and Scottish system to the Continent *vid* Tilbury and Dunkirk will be begun on the night of Sunday, May 15th. Tilbury Station has been rebuilt by the railway company, and a deep-water pier provided by the Port of London Authority.

THE General Electric Company of America announces that it has succeeded in making metal railroad sleepers from used rails. As a result of tests of the sleepers in the Glenville, N.Y., yards of the Delaware and Hudson Company, the vice-president of the line has decided to substitute the new sleepers for wooden ones. A considerable saving in cost is said to be possible. The metal sleepers cost 60 cents each and the wooden ties 2·80 dollars. The scrap value of the metal, however, is 2·50 dollars, but that may still be recovered after the metal has been used as a sleeper.

THE annual Exhibition of the Model Railway Club was recently opened at the Kingsway Hall. On one side of the room, on a long track, was running a large model of a Baltic tank engine of the London, Midland and Scottish Railway, Tilbury Section, worked by steam, with paraffin as fuel. There were trains of all sorts and sizes, from model locomotives large enough to haul several passengers, to engines small enough to be held on the palm of the hand, sections of railway lines, stations, including an excellent reproduction of Poplar Station, signal boxes, and tunnels. A section of a complete railway, made by two brothers, embodied an Underground station and a countryside station, the latter including level-crossing gates, a Post Office pillar box, and a white line for the guidance of motorists. One of the most interesting of the exhibits was a model of a tank locomotive used on the Southern Railway, made by Mr. A. Knock, from rubbish found in a dust destructor. Its approximate cost, without labour, was 27s.

DURING the disturbed period through which Ireland was passing a few years ago the mails for Belfast, in order to avoid their being interfered with, were taken off the Holyhead-Kingstown route. To reach Belfast in time for business they were then sent *vid* Fleetwood, but that necessitated dispatch from Euston at 6.10 p.m., and often the letters were not posted in time. The alternative route was *vid* Stranraer and Larne. The mails then left with the postal train at 8.30 p.m., but with so much later a start they did not reach Belfast until 9.30 a.m. Mails from Belfast to London suffered more. If sent *vid* Larne they left York-road Station, Belfast, at 6.25 p.m. and were due at Euston at 7.10 a.m.; if by Fleetwood they were dispatched about three hours later, but did not arrive in London until nearly noon. The Larne-Stranraer route to London could be improved and the mails arranged to reach Crewe, and therefore London, earlier, but only by the expense of a special postal train from Stranraer, and that, it is thought, is not justified. It has now been decided to revert to the Kingstown route.

THE Canadian Government has appropriated 5,000,000 dollars for the completion of the Hudson Bay Railway to the Bay. The Hon. Charles Dunning, Minister of Railways, in asking Parliament to vote this amount, explained that, in addition to securing the services of Mr. Frederick Palmer, the eminent English engineer, to report on the comparative merits of Port Nelson and Fort Churchill as termini for the railway, the Government intended to place the areas under a year's air reconnaissance. He stated that, while there were no insurmountable obstacles to construction on the railway to Fort Churchill, the Government hoped that in view of the expenditure already made on Port Nelson the latter would prove to be the logical location. None of the investigation work would involve delay in the completion of the Hudson Bay Railway to its water terminus, or in the ultimate completion of the harbour. It would take six years fully to complete the work of dredging the proposed 300ft. ship channel up the Nelson River, the cost of which would be over 7,000,000 dollars, while another 7,000,000 dollars would be required for docking and cribbing, about 5,000,000 dollars for a 4,000,000-bushel capacity elevator and 300,000 dollars for a lighthouse. The total cost for Port Nelson facilities, therefore, would be about 20,600,000 dollars, allowing for engineering costs.

ONE of the four collisions between trains and road vehicles at level crossings which the Ministry of Transport considered necessary to inquire into during the twelve months ended in November last occurred on October 27th at Roudham, on the Brandon and Norwich section of the London and North-Eastern Railway. In that case a motor lorry was run down by a goods train, and one of the three occupants of the road vehicle was killed. The crossing in question differed from that at Naworth, near Carlisle, where a char-à-banc was struck on August 30th, in that, whilst the latter was on a line opened before the Board of Trade had power to inspect railways, Roudham was opened subsequently and was inspected on July 7th, 1845. From the description given in the report on the accident by Lieutenant-Colonel Mount, it is reasonable to suppose that the condition of affairs at the crossing to-day is as it was in 1845. The gates are of the field type, 12ft. wide, are opened by hand away from the line, and are not protected by signals. A lodge is provided and until less than five years ago the gate keeper was literally on duty for twenty-four hours. A new appointment, however, objected to the lack of rest, and he was given some relief, and eventually three men worked eight hours each. It was whilst two of those men were changing duty about, 10.5 p.m., that the goods train approached and the men, being busy discussing some instructions they had received, failed to warn the road vehicle. Between 1922 and 1925 the daily average of road vehicles increased from 308 to 607, and their aggregate average estimated tonnage from 527 to 925. The case is therefore one for the substitution of a bridge for the crossing, and Colonel Mount recommends that course.

Notes and Memoranda.

THE February output of coal in France was 4,288,000 tons, against 4,458,000 tons in January. The output per working day showed a small increase, there having been one working day less in February than in January. The daily rate of production of pig iron fell from 25,550 tons in January to 25,170 tons in February.

PRODUCTION of automobiles in Canada during February numbered 18,655 cars, an increase of 18 per cent. over the 15,376 made in January, but slightly less than the 18,838 reported for February of a year ago. For the two months ending February, the cumulative production totalled 34,031 cars, as compared with 34,317 reported for the first two months of last year, and 23,188 during the corresponding period of 1925. Of the 34,031 cars produced up to the end of February, 13,621, or 40 per cent., were made for export and the rest, 20,410, or 60 per cent. of the total, were intended for sale in Canada.

THE method of watering high roads with sulphite lye, which on drying binds the dust together and makes the track solid and smooth, has constantly gained ground in Sweden during the past few years, and large quantities of lye, which is produced as waste matter at the sulphite mills and is very cheap, are even being exported. It is now reported from Stockholm that a Norrkoeping engineer, Mr. Robert Karlberg, has now invented a method of making the lye still more efficient by mixing it with a hygroscopic salt which attracts humidity from the air and keeps the track slightly moist.

A NUMBER of methods are employed scientifically for the study of the movement of flames in gaseous mixtures. In a paper by O. C. de C. Ellis, entitled "The Study of Flame Movement" (Safety in Mines Research Board, Paper No. 32, H.M. Stationery Office, Adastral House, Kingsway, London, W.C. 2, price 1s. net), the principal methods are outlined. Some of the earliest enabled the speed of the flame to be measured under different conditions of the gaseous mixture, but did not permit a close determination of its mode of movement. This obstacle has been largely overcome by a new method of "snapshot" photography described in the paper, by means of which the spreading of the flame in a totally or partially closed vessel can be studied.

SOME remarkable operating results obtained at the Columbia Power Station of the Columbia Power Company are referred to in the April issue of *World Power*. This station was started up in the early part of January, 1926, and during the month of December last, over 41 million units were sent out, at a thermal efficiency represented by an expenditure of 12,495 B.Th.U. per unit. The average calorific value of the coal as fired was about 13,700 B.Th.U. per pound, and the fuel per unit sent out has thus reached the remarkably low figure of about 0·91 lb. This station employs powdered fuel, and the steam pressure is 600 lb. per square inch. The load factor is in the neighbourhood of 75 per cent. A further noteworthy feature of this station is the high generating voltage of 13,500.

AFTER protracted laboratory work conducted at the Fushun Collieries, Japan, the first experimental shale-oil distillation furnace was started in the latter part of 1926 at that plant. This furnace is 3ft. in diameter and 50ft. high, and has a capacity of 40 tons. It is of the internal heating type, and is so designed that the gas will be returned to the furnace for re-use. If this furnace comes up to expectations the plan is to build forty-seven additional 40-ton furnaces. It was found at the Tokuyama fuel depôt that by mixing one part of the shale oil produced at the Fushun Collieries with two parts of crude Borneo oil, a product was obtained that would be satisfactory for marine purposes. Besides shale oil, of which an annual output of 25,000 tons is expected when the plant is completed, by-products will also be obtained. The shale from which the oil is extracted is found in great quantities at the Fushun Collieries, and can be mined at low cost.

THE use of secondary batteries in surface warships is comparatively limited. It has not been found desirable or practicable to fit them as a stand-by supply for the main generating plant of the ship. The electrical supply to the gunnery and torpedo control circuits, telephones and certain navigational instrument circuits, however, necessitates small secondary batteries as a stand-by. Batteries are also employed to give an auxiliary lighting supply at low pressure in certain important spaces, such as gun houses, while they are also used for wireless purposes and for portable hand lamps. The most important field in which secondary batteries are used in warships is in submarines, where the whole of the power for underwater propulsion is provided by this means. The power required for this purpose, the comparatively small space available for the battery, the absolute reliability required and the onerous conditions of working, make the provision of a reliable battery an extremely difficult problem.

A PAPER by Mr. B. C. Churcher, published in the April issue of the *Journal* of the Institution of Electrical Engineers, describes null methods of measuring the ratio and phase displacement of two alternating voltages. The methods are particularly applicable to high voltages and are discussed in connection with the testing of power transformers and potential transformers. An important feature is the use of a capacitance potential divider in place of the resistance type of potential divider which has hitherto been used. Capacitance potential dividers possess considerable advantages over those of the resistance type from the point of view of simplicity and low cost of equipment and ease of operation, while the accuracy can be made as high as is desired. The maximum voltage at which the use of resistance potential dividers is practicable is in the neighbourhood of 30 kilovolts, whereas there is practically no limit to the voltage at which capacitance potential dividers can be used. The theory of a method of measuring the ratio and phase displacement of transformers is given and the operation of the method is illustrated by a test on a 66,000-volt potential transformer. Suggestions are made for the developing of an apparatus for routine industrial testing, and it is pointed out that a robust construction and adequate safety to the operator could be secured while retaining ample accuracy for commercial purposes.

Miscellanea.

AFTER being closed since March 1st, Marlow Lock was recently reopened for river traffic. The lock, which is one of the oldest on the Thames, has been entirely reconstructed at an estimated cost of several thousand pounds. The sides of the lock, which were formerly of timber, are now made of reinforced concrete. The lock has been deepened throughout, and special new gates have been erected at both entrances.

THE new light cruiser Berwick, of 10,000 tons displacement, which was launched by the Fairfield Shipbuilding and Engineering Company, Govan, in March of last year for the Admiralty, has now been practically completed. She has been berthed in dry dock at Govan for cleaning preparatory to running trials. The Berwick, which is one of the new "County" class of British cruisers, is in general design a sister ship to the Norfolk, now under construction at Fairfield, the Shropshire at Dalmuir, the Australian cruisers Australia and Canberra at Clydebank, and several vessels at English yards.

THE Belfast Harbour Commissioners have in contemplation an important improvement scheme, estimated to involve an expenditure of £30,000. At a recent meeting a proposal from the Joint Traffic and Navigation and Works Committee was considered, recommending the strengthening of a portion of Albert Quay in order to carry electric cranes, and that three additional 5-ton electric cranes with the necessary rails be provided. Also that certain rearrangements be carried out which would enable working spaces on the quay to be increased by 1800 square yards. The chairman, Mr. R. E. Herdman, D.L., said the Committee was unanimous in making the recommendation, as it would mean a great improvement.

OUR contemporary, the *Electrical Review*, gives a description of the 1200-kilowatt oil-driven plant at Ashford, the adoption of which was sanctioned by the Electricity Commissioners in view of the fact that the cost of energy in bulk from an economical generating station less than 20 miles away would have been far more than that of the locally generated supply, owing, we believe, to the capital charges on the transmission line. It is not suggested that this particular instance affords a solution to the general problem, but it certainly indicates that the day of the small power station is not over; and if, as is probable, cheap British oil becomes available from the low-temperature distillation of coal, its position will be greatly strengthened.

IN a recent competition for a design of a bridge across the Rhine between Cologne and Mülheim, at one of the widest points of the river, the first prize was secured by the Krupp firm with a design prepared by Professor Peter Behrens, consisting of a single arch of 1000 m. (3281ft.) span, without any supports in the stream. The municipal authorities of the city of Cologne, however, have now published reports of various bridge experts, who one and all condemn Professor Behrens' design. Their main objection is based on the fact that the abutments would rest on a gravel bed and therefore be liable to lateral movements, which would endanger the safety of the bridge. In their opinion, an arch bridge would be altogether out of the question under such conditions, a suspension bridge being the only feasible scheme.

A SETTLEMENT has been reached concerning the Birkenhead entrances to the new Mersey Tunnel. The entrance at Woodside, Birkenhead, is to be taken farther back to Bridge-street and Chester-street. This will shorten the main tunnel and increase the gradient to 1 in 20, as against the gradient in the original plan of 1 in 30. The very considerable saving effected by this alteration will be devoted to the provision of a narrow tunnel to Rendel-street and Marcus-street, for docks traffic only, with a gradient of 1 in 30. The tunnel will be 27ft. wide, as compared with the 44ft. width of the Woodside tunnel. The saving, however, will not cover the total cost of this extra tunnel, and the further £200,000 necessary will be provided as follows:—Ministry of Transport, £100,000; Birkenhead Corporation, £50,000; Liverpool Corporation, £50,000.

CANADA'S national campaign to protect her forests from the scourge of fire has taken one crystallised form in the setting aside of a "forest week" each year, in which a great educational campaign having for its object the elimination of human carelessness as a factor in destroying Canada's forest resources is carried on. This year a proclamation of the Governor-General fixed the week of April 24th to 30th as "Canadian Forest Week." The proclamation set forth that Canada's forest resources is threatened with two great dangers, both of which are man caused and therefore preventable. The one, of universal carelessness, is destruction of the timber, young growth, and even the very soil which produces it, by fire, and the other, the use of wasteful and destructive cutting methods without any thought of ensuring a new crop. Through the mediums of the platform, the Press and wireless it is hoped that all Canadians may be stirred and encouraged to a sustained effort in promoting the conservation of this valuable resource.

IN a paper read before the Junior Institution of Engineers on April 22nd, Mr. C. D. Holland (member) discussed the design and construction of shock absorber units for land plane undercarriages and gave figures and formulæ for the determination of such items as the magnitude and direction of landing shock, the energy to be absorbed by the absorber unit, and the fluid resistance of the oil dashpot or "oleo," as it is generally called, when referred to in aircraft undercarriages. Mr. Holland also gave particulars for the calculation of the rebound velocity. In the foreword to his paper Mr. Holland said that, in view of the youthfulness of air transport, passengers' minds were too fully occupied with anticipated or realised pleasures to be critical about the bumps and jars they experienced when the machine took off and landed. The criticism of Service pilots had to be contended with, as the Government was the largest customer of any aircraft concern. It was the designer's business to foresee the trend of modern development, such as "stalled landings," and the criticism of experienced air passengers, particularly as there were seven very active flying clubs in existence already.

PULVERISED COAL PLANT AT THE POPLAR ELECTRIC GENERATING STATION

INTERNATIONAL COMBUSTION, LTD., LONDON, ENGINEERS

(*For description see page* 466)

FIG. 3—RAYMOND PULVERISING MILLS

FIG. 4—LOPULCO DRYERS AND EXHAUSTERS

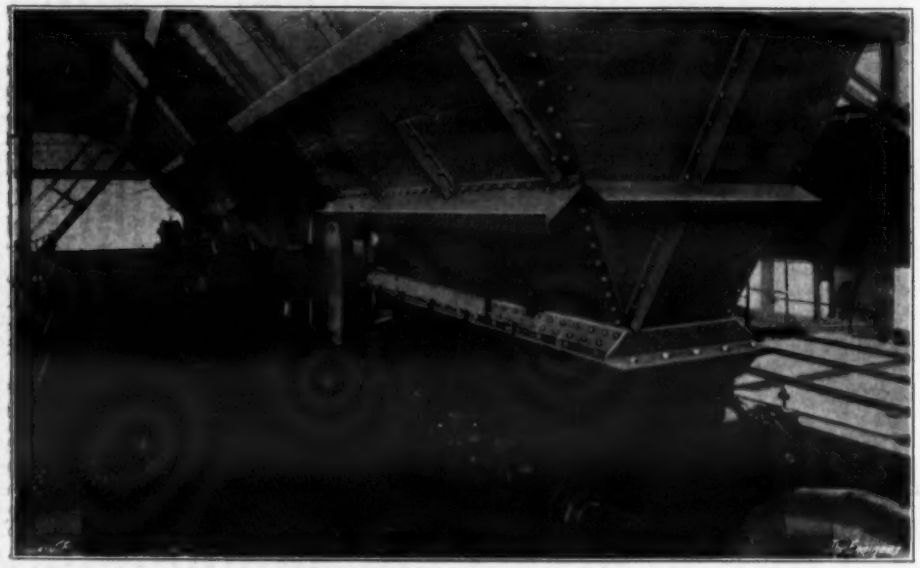


FIG. 5—PULVERISED COAL FEEDER GALLERY

FIG. 6—INTERIOR OF BOILER-HOUSE

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TO CORRESPONDENTS.

*** All letters intended for insertion in The Engineer or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

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By arrangement with Reuter's Engineering Service, The Engineer contains the latest news from all parts of the world which is likely to be of interest to engineers.

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Sixteen-page Supplement—"The Metallurgist."

The Metallurgist

THE APRIL NUMBER OF THE MONTHLY METALLURGICAL SUPPLEMENT TO "THE ENGINEER" ACCOMPANIES THIS ISSUE

THE ENGINEER.

APRIL 29, 1927.

Co-operative Industrial Research.

It is now eight years since a beginning was made by the Department of Scientific and Industrial Research with the policy of promoting schemes under which firms engaged in the same industry may, with assistance from the Government, co-operate in conducting scientific investigations in their common interest. Year by year from the annual reports of the Department we have learnt something of the success, and of the setbacks, which the policy has encountered. Year by year, however, the reports show an increasing degree of prolixity and an increasing tendency to concentrate on the administrative side of the policy rather than on the practical results which it has produced. It is to be feared that many busy manufacturers have failed to take a proper interest in the research associations for lack of a concise general statement of the work they have done and are capable of doing, and the measure of support which they have received from their industries. The Department has now remedied the position by publishing a pamphlet entitled "Co-operative Industrial Research," from which, without undue trouble or expenditure of time, anyone interested can obtain a straightforward summary of the scope and working of the research associations established under the Department's policy. A frank statement of facts, free from the verbosity of the annual reports, was greatly needed. All the associations have not been equally successful; the Department itself has never disguised the fact that some have, indeed, been failures. Too much attention has been paid by industrialists to the less successful associations. A general review of the working of the policy on its practical side sets the subject in proper prospective.

Since the Department's policy was initiated in 1918, a total of twenty-six research associations has been established. Two of them have become defunct, namely, those concerned with the glass and the Portland cement industries. The Glass Research Association was wound up because of inadequate financial support from the industry. The work of the Cement Association was taken over and is being continued by the Associated Portland Cement Manufacturers outside the Department's scheme. In addition, a third body, the Iron Manufacturers' Research Association, has suspended its activities after completing an investigation of mechanical puddling. The Department has done more than it originally promised to assist the establishment and running of the associations. Up to the end of March, 1926, it had paid in grants to the associations a total sum of £570,000. The industries served contributed for their part a sum of £564,000, so that the Department has exceeded its undertaking to contribute a pound for every pound subscribed by those deriving benefit from the associations. It has, too, in most cases consented, after independent investigations, to continue the payment of grants beyond the period of five years originally arranged. The value extracted from the assistance granted by the Department has varied widely. A particularly favourable instance is provided by the Electrical and Allied Industries' Research Association. In the course of five years this body has received by way of grant a total sum of £50,000 approximately. By its investigations on the safe loading of buried cables, on transformer oils, on the construction of overhead transmission lines, on oil circuit breakers, on insulating materials, and in other directions, it is estimated that a prospective annual saving of £1,100,000 has accrued to the electrical supply industry. This association is supported by nearly 85 per cent. of the capital invested in the electrical manufacturing industry and by about one-third of the capital in the electrical supply industry. An equally well supported body is the Cotton Industry Research Association. Over 84 per cent. of the capital invested in this industry is represented by the members of the Association, the spinning and the finishing branches contributing almost equally. This body in the course of seven years' existence has received grants from the Department totalling nearly £75,000. Its work has already covered a wide range, and should lead to important technical developments. Two instances may be given of its success. An investigation of the carding process has led to the design of a simplified engine which is at least as efficient as the present type, and which occupies considerably less space and costs less to produce. The insulating power of British manufactured cotton was until recently inferior to that of foreign produced material. The application of the results of the Association's research into this subject has now completely reversed the position. These two associations, the electrical and cotton, serve two closely defined, highly organised industries. There are other industries which have no precise limits or which are technically backward in their organisation. To establish a successful research association for such an industry is a task of increased difficulty. Yet that it can be done is shown by two instances, namely, by those of the Cast Iron and the Non-ferrous Metals Research Associations. The Cast Iron Association in five years has received a total grant of £13,500. The industry is widely scattered and includes a large number of small jobbing foundries, many of which cannot be expected to join the Association. It is estimated that the Association includes about one-eighth of the total number of foundries in the country, and about one-quarter of those which would derive substantial benefit from the research work undertaken. The non-ferrous metals industry is too ill-defined to permit of any estimate being made as to the extent to which its research association is receiving its support. This association has been granted £28,000 during six years. Both these bodies are, in spite of the difficulties they have had to encounter, doing valuable work. Several members of the Cast Iron Association, it is recorded, are by its help saving £250 a year on their fuel bill, while others have had placed at their disposal a remarkable improvement in the production of malleable castings. Of the high industrial importance of the work conducted by the Non-ferrous Metals Association there can be no doubt. It was this body, for example, that was responsible for the discovery of the 80/20 nickel chromium alloy which at elevated temperatures has a higher strength and resistance to creep than any other material, ferrous or non-ferrous, previously tested. It has also conducted valuable investigations into die casting, soft solders, cast copper and brass sheets, and has been entrusted by the four railway groups with the conduct of an investigation into the wastage of copper stays and fire-boxes in locomotives.

These examples serve to show that it has been found possible to organise research associations, and to run them satisfactorily under greatly differing conditions and to meet greatly differing needs. Success, as we have said, has attended the research associations established for such clearly defined industries as the electrical and the cotton. It has also attached itself in a highly promising degree to such a vaguely defined body as the Refractories Research Association, a body supported by manu-

facturers and users of refractories, including thirteen iron and steel manufacturers, three engineering firms, five builders of coke ovens, seven coal and quarry owners, six metal manufacturers, two electricity undertakings, one gas undertaking, and two technical societies. With these instances of successful achievement in mind, it is greatly to be regretted that some of the associations have failed to establish themselves on an assured basis. The most outstanding example in this category is probably the Glass Research Association. Everything seemed to favour the likelihood of success. The industry was compact, and fundamental changes in the processes of manufacture were taking place and provided a wide scope for useful research. The Association was granted more than the usual pound for every pound subscribed, but in spite of these facts it had to be wound up because of "inadeqaute financial support from the industry." Certain of the other associations are, it is clear, being inadequately supported at the present moment. They must not be allowed to go under because of a failure on the part of those whom they are designed to serve to recognise their potential value. The research association scheme is undoubtedly a sound one in principle. It is of benefit to both the large and the small firm. In most cases the associations are supported to a disproportionate extent, in some instances almost entirely, by the large undertakings. With the fund available for the Departmental grants almost fully committed as it now is, the outlook even for the associations that have made good is not completely assured. In order that it may be made so, the associations must become independent of Government assistance. To that end, it is essential, in the first instance, that the British manufacturer should be brought to realise the true value of co-operative industrial research. Thereafter, it may be found practicable and desirable to introduce, as some are already suggesting, a voluntary or compulsory scheme of contributions, based on the raw materials used or the outputs of individual firms.

The Kelvin Lecture.

As Professor Marchant remarked in the introduction to his Kelvin Lecture—delivered on Thursday, April 21st, before the Institution of Electrical Engineers, and published in abstract elsewhere in this issue—the bewildering variety of Lord Kelvin's genius makes it easy for a lecturer to find a subject in which he was a pioneer. The subject which Professor Marchant selected, "High-frequency Currents," was one to which Lord Kelvin gave his attention. Many modern developments are based on the investigations described in his paper on "Transient Electric Currents," published in the *Philosophical Magazine* in 1853. To Lord Kelvin belongs the credit of having traced out the oscillatory character of a condenser discharge, a phenomenon which had previously puzzled many investigators. Subsequently it was shown experimentally that the oscillations that Kelvin predicted actually existed, and from that time onwards the subject of high-frequency currents became one of ever-increasing interest and importance. Hertz's researches on electro-magnetic waves were based on Kelvin's paper, which may be regarded as the foundation of subsequent developments in high-frequency current work. Although currents with frequencies in the neighbourhood of a million cycles per second are now used in every-day electrical engineering, it is improbable that the early investigators imagined that such high-frequency currents would ever be produced commercially. The Poulsen arc and the oscillating valve which have made the production of very high-frequency currents possible are, relatively speaking, modern devices, although in both cases the frequency of the current is determined by the electrical constants of a circuit containing capacity, inductance and resistance, such as that investigated by Kelvin.

Many high-frequency problems have been grappled with since Kelvin's time. High-frequency phenomena in dielectrics provide one of the subjects that have received attention, for under the influence of high frequencies, dielectrics often behave in an abnormal manner. Using frequencies of between 85,000 and 120,000 cycles per second and a maximum pressure of 14 kilovolts, Goebeler has found that the breakdown pressure of glass is only one-third of that at 50 cycles. With porcelain it varies from one-third to one-half, whilst fibrous materials at high frequencies become practically conductors. These phenomena are explained by Professor Marchant by the so-called polarised theory of dielectrics. Makers of insulators for the ordinary frequencies of power supplies have often been puzzled by the behaviour of their goods when exposed to the influences of high-frequency currents. When, for instance, the Leafield wireless station was put into operation, it was found that if the aerial current were increased above 190 ampères, the insulators on the aerial stays "brushed" over. When removed, they practically crumbled in the hand, and an inspection of the broken parts indicated that they had been subjected to intense heat. Again, during some building alterations to the aerial tuning inductance room, a temporary wooden partition, about 8ft. away from the coil, became damp, and afterwards caught fire as a result of being in the field of high-frequency currents. These examples of the peculiar behaviour of insulators serve to show how important it is that the theory of high-frequency phenomena in dielectrics should be properly understood. Similarly, the magnetisation of iron at high frequencies calls for study, for as Professor Marchant showed, although iron remains a magnetic material at high frequencies and with suitable precautions may be used at the highest frequencies that can be produced, eddy current losses become very pronounced. The actual loss in silicon iron at a frequency of one million cycles per second is no less than 1 kilowatt per pound, with a maximum flux density of one hundred lines per square centimetre, as compared with the normal figure of about 1 watt per pound at a frequency of 50 cycles with a maximum flux density of 10,000 lines per square centimetre. Apart from mechanical considerations, therefore, the task of building alternators for generating very high-frequency currents presents great difficulties, and it is fortunate that other methods of producing such currents are available. High-frequency disturbances in distribution networks and overhead lines form a branch of the subject that concerns power engineers. Although on the whole these disturbances have not as yet led to very serious troubles on the power systems of this country, with the increasing size of distributing high-pressure networks, the possibility of the occurrence of surges arising from excessive load fluctuations requires consideration. In a transmission system the stored electro-static and electro-magnetic energy may be considerable, and changes caused by switching operations and faults give rise to corresponding changes in this energy, resulting in some cases in very objectional pressure rises. The readjustment occurs in the form of an oscillation which may be of high frequency, thus showing that wireless and electric power engineering are not so widely separated as they are generally supposed to be. The study of lightning flashes—another matter discussed by Professor Marchant—has given rise to much investigation in America, where during the past year measurements have been made of the voltage produced by lightning in transmission lines. As Professor Marchant explained, the use of the Dufour oscillograph enables photographic records to be obtained of transient voltages lasting only a few millionths of a second. Lightning has not, however, given rise to much trouble in this country, where overhead lines are relatively scarce.

By far the most popular branch of the subject is, of course, the use of high-frequency currents for the production of electric waves for wireless communication. Just as light is radiated from the sun by means of waves through the ether, so are electric waves radiated when the ether is subjected to an electrical disturbance, produced by high-frequency currents. While Lord Kelvin does not appear to have been at all enthusiastic about the possibility of wireless communication by means of electro-magnetic waves, the fact remains that the paper he read in 1853 had a marked bearing on the subject. It was, however, purely a scientific paper, dealing with a rather abstruse point in connection with electrical discharges, and not until many years afterwards did wireless communication begin to take practical form. Modern wireless developments are, of course, the outcome of the work of various investigators, such as Marconi, Lodge, Duddell, Poulsen, Fleming and De Forest. To Lord Kelvin, however, belongs the credit of having set forth the principles of the oscillatory circuit without which little progress could have been made. No electrical subject has created more general interest or has led to more remarkable results than that chosen by Professor Marchant for his Kelvin Lecture, a fact which serves to show that an investigation carried out for the sole purpose of acquiring knowledge concerning a specific problem may ultimately lead to developments of very great importance.

The Modern Steam Engine and Internal Combustion Motors.

By MAURICE DEMOULIN.

No. III.*

It is considered desirable in most central stations to increase the rating of boilers and the rapidity of combustion. But since it is impossible to resort to closed stokeholds, and increasing the height of chimneys is neither practical nor efficient, draught has to be produced by fans delivering under the grates or, on the contrary, by induction. The most modern stations, at least in France, as far as I know, and not the smallest, are now provided with induced draught produced by fans fitted in the uptakes, the gases being sufficiently cooled by their passage through the feed-water heaters. Induced draught, when it can be resorted to, is always the best, as is shown conclusively by the locomotive. It enables all rates of combustion to be attained, offers great flexibility, an easy control of steaming and pressure, and gives a greater equality of draught on the grates, less lifting of the coal than does forced draught, and the chimneys are reduced to short steel pipes. It is also employed in Great Britain, but perhaps not on as great a scale as it might be. The system has, I think, a great future before it.

It has been noticed in some of the boilers above mentioned, that the brick work of the furnace walls is exposed to rapid deterioration, owing to the high temperature to which it is submitted, which results in costly maintenance and the stoppage of boilers for repairs One of the most recent improvements applied to some types of these boilers consists in protecting the walls of combustion chambers by rows of vertical water tubes, communicating with the boiler itself. This arrangement offers some complication, but if it can preserve the walls and avoid frequent repairs, it must be welcomed as a useful innovation.

In some electric stations burners for colloidal fuel —50 per cent. of oil and 50 per cent. of finely powdered coal—are being tested, the object being to increase the rating to meet the maximum loads at peak hours.

Preheating of air intended for combustion is largely used. The principle is far from being new, the Howden system having been fitted on board many ships during the past forty years.

Feed water heating by waste gases, not hot enough for making steam, is an absolutely general practice, one which has perhaps been the object of most attention and care and has greatly contributed to the high efficiency obtained. In some plants it has been highly developed; there are many types, but it is not the place to describe them here. In the most recent types of Ladd-Belleville boilers the feed heaters are made of a bundle of steel tubes, very similar to superheaters, but with a much greater heating surface and entangled in a very ingenious manner so as to occupy the least space and present the maximum area to the gases which have a very sinuous path to follow.

As I have said above, several plants thus equipped have an efficiency that reaches a very high figure.

These improvements, which lead to an increase of efficiency, are not applied to such an extent to marine engines in which the question of weight and bulk is of so much importance. Thus, mechanical stokers have only been experimented with and have not yet entered into practical use, which is not surprising when we remember the difficulties of application and that the pitching and rolling would prevent a regular advance of the coal. Underfeed stokers are possibly the more practical in such circumstances, though not perfect; far from it in all but calm waters. Pulverised coal seems to have some future for marine use, but there are yet many difficulties to overcome. For the present, only fuel oil gives complete satisfaction at sea, but it presents the inconvenience of being in Western Europe an imported fuel.

In what concerns these applications, the preference for water-tube boilers is influenced, as is well known, by other reasons than those which apply to plants on land. Merchant ships, if we except some recent and fast passenger steamers and liners, are most generally fitted with cylindrical or Scotch boilers. Though of a very questionable design, they are yet well adapted for tramp steamers, trawlers and all kinds of ships having no pretension to speed or material progress. The Scotch boiler has remained the standard type and has not received for the past forty years any real modification, apart from strengthening to meet the increase of working pressure. It owes its favour principally to its easy firing, which results from the large quantity of water it contains, and because it allows, with less inconvenience than other types of boiler, the presence of some salt water, but it is not free from priming with slightly brackish or rather greasy feed water. When employed on Channel steamers or other vessels of the same class liable to frequent and rather long stoppages in the terminal harbours, it needs some nursing and a great deal of care to avoid leakage at some of its inside seams and the riveting at the tube plates, but the engineers in charge know their duty in this respect.

However, and if we except steamers of the mercantile marine mentioned above, the drawbacks of this type of boiler are such as to

* No. II. appeared April 22nd.

cause some surprise at its general adoption. It can with difficulty be considered rational to employ pressures up to 230 lb.—which cannot be surpassed with this type of boiler—with shells reaching a diameter of 18ft. and often more and large flat plates strengthened with longitudinal stays, and needing sometimes to be consolidated by doubling plates. The combustion chambers, subject to external pressure, must be supported by a great number of stays, and the cylindrical furnaces are subject to collapse in the event of an accumulation of scale or greasy deposits or even of insufficient circulation. This circulation is indeed very defective, a circumstance detrimental both to good evaporation and to the maintenance of the interior. Several devices have been tried or are used to accelerate this circulation artificially by means of hydrokineters, pumps or baffles. We find here one of the principal reasons why the combustion and evaporation are limited to a relatively low rate, in order to avoid on the heating surfaces pockets of steam and great stresses on inside seams; the high and relatively narrow water spaces do not themselves allow an active circulation, and the numerous and very closely spaced screw stays make inspection and cleaning difficult; some parts are not even accessible at all.

These boilers are rather economical in coal, but very large and heavy for their steaming capacity, and if placed underneath the passenger accommodation and of large size, can only be removed with the help of powerful cranes and equipment which is to be found only in important harbours or large shipbuilding yards.

The cylindrical boiler has rendered great services, and it would be unfair to criticise it in what concerns the past. I only mean to say that it has arrived at its limitations and it does not permit the progress that should be expected. I sincerely believe that it is to be considered as almost an old-fashioned boiler, which has only survived in the lack of a type of water-tube boiler fully adapted to the long sea voyages of the mercantile marine. The cylindrical boiler is already out of place on fast ships. It is a good and serviceable generator, as said above, for some categories of plain ships without pretence, but no progress can be expected from it without important changes.

Distilled water is invariably used in water-tube boilers, and all leaky joints are a source of water waste and must be avoided. The adoption of these boilers for long passages depends largely on the good condition and maintenance in perfect order of the condensers and on the improvements that can be effected to make them as water-tight as possible. Progress has been made of late in this direction, but the absolutely water-tight condenser, for a long period of service, has yet to be built. There is also the question of greasy deposit, a problem that would be solved by the use of turbines if there were no auxiliary engines.

Some makers, and at least one important French and one Scotch shipbuilding yard, have recently produced an interesting type of boiler which I shall call "mixed," but which is known under the name of "at accelerated circulation;" it works well and has a greater steaming capacity than the ordinary marine boiler and has given an efficiency of 94 per cent.; but is little known yet, I believe. The fore part of the boiler is cylindrical with inside corrugated furnaces as usual, but the ordinary combustion chambers and all the screw stays are done away with. The flames and gases from the furnaces pass through a special and short water-tube boiler enclosed in a refractory brick chamber, of which the upper and lower drums are in connection with the water and steam space of the main boiler. The gases then escape through smoke tubes disposed in the ordinary way above the furnaces. With such a system, the circulation of water inside the cylindrical boiler is very much increased. This boiler, however, is still as heavy and bulky as the marine cylindrical boiler, of which it is simply an alteration or an improvement, but really important if we consider the question of circulation and steaming capacity.

The introduction in the Navy and on some fast passenger steamers of the water-tube boiler with tubes of relatively small diameter—Thornycroft, Normand, Yarrow, &c.—has been an important step in allowing, especially when fired with fuel oil, and completed by the adoption of turbines, the production of propulsive machinery sufficiently light to obtain the very high speeds of modern cruisers and destroyers. It must be noted that the locomotive boiler which admits, on the road, of the highest rate of combustion ever recorded, has always failed on torpedo-boats and light fast ships, to give good results, these ships being too shallow to allow a sufficient depth of fire-box. The result is, on one side, incomplete combustion and low efficiency, and on the other, great stresses on the tube plates, these being too near the grates, with sometimes real damage, and at least frequent and very serious leakages in the tubes, in the case of rapid changes in the rate of combustion. Moreover, the locomotive boiler is not made for heavy steaming for long continuous periods without washing out and sweeping of the tubes.

In short, for all large plants, such as central stations and on sea for very fast ships, we find the use of water-tube boilers almost universal. On shore the working pressure is now 450 lb. and more, and boilers have tubes of relatively large diameter and sometimes very long when they are vertical or nearly so; automatic stoking or pulverised coal is used; the whole plant being completed by superheaters and feed-water heaters, so as to make use to the utmost of the heat delivered by the combustion of the fuel.

At sea, tubes are of a smaller diameter—except in types of boilers belonging to intermediate classes, in use for a long time, and for which the land and marine types are very little different—and the boilers are equally provided with superheaters and are generally highly rated. Here, the question of weight is important and the evaporation is made as high as consistent with a sufficient efficiency and the maintenance of the boilers.

Other stationary plants, such as those belonging to works, factories, mills, &c., do not offer to-day much interest since the power developed is small—except for mines or rolling mills—and particularly because, in many places, the electric energy is taken from public supplies. Moreover, in some factories, the cost of fuel is a small item in the general expenses. Electric energy, besides, dispenses with boilers and engines survey and maintenance. I am not well aware of how the things stand in Great Britain now, but I can assert that within a radius of, say, 30 or 40 miles of Paris or Lyons—which have become very important industrial centres—there are very few manufacturers using steam motive power, all power generation being concentrated in large electric stations where it is produced very economically.

(To be continued.)

Literature.

Atomic Theory; An Elementary Exposition. By ARTHUR HAAS, Ph.D., Professor of Physics in the University of Vienna. Translated by T. VERSCHOYLE, M.C., Ph.D., A.R.C.S. London: Constable. 222 pp., large 8vo. Price 10s. 6d.

THE title of this book is somewhat misleading; it is neither a systematised treatise on atomic theory, nor is it elementary in the ordinary sense of the word. It is a short, concise review of the organic relationship of modern physical discoveries to one another and to the atomic theory, with the quantum and electron theories as supplying the means of co-ordination. To the physical chemist who has got all the material piecemeal as it appeared, it is a remarkably welcome work; something he has felt the want of for years. On the other hand, it does not bring the reconciliation of the atomic theory with the demands of pure reason the slightest shade nearer. Probably the book might better be called "Theory of quanta," &c., as it starts by defining and calculating the values of elementary quanta, one of which is the mass of the hydrogen atom. For all practical purposes, quanta are infinitely small, but possessing distinct quantity and other characteristics, and hence they are a kind of materialisation of differentials, which French mathematicians characterise as "des infiniment petits." Physics finds a finite limit of the infinite, whilst reason does not, and probably never will. Professor Haas starts with the experimental proofs of the existence of these limits, new to the physicists of the nineteenth century. The very first paragraph, giving Millikan's direct determination of the elementary quantum of electricity, opens the eyes of the reader to the wonderful advance of modern experimental art. A single globule of oil, one ten-thousandth part of a millimetre in diameter, is observed falling under the influence of gravity to reverse its motion by the action of an electro-static field acting vertically upwards. The speeds are slow and uniform, and it is found that the upwards speeds vary by steps, which are multiples of a minimum, which is supposed to be caused by the oil drop picking up one quantum of electricity by collision with a charged molecule of air. From these data the value of the elementary quantum of electricity is derived by the author in a clear, concise way, which is easily followed if you attend to the transformation of the constants yourself.

So the book proceeds from one proposition to another, almost like Euclid. Over radiology, which introduces the electrons as another elementary quantum, we get to a dynamical treatment of spectrology, Moseley's "natural" sequence of the element, &c. &c., right through practically all new discoveries in physics, which bear on the subject. The arrangement of the matter is pedantically orderly, and the book is undoubtedly intended primarily for serious students of physics. The mathematical apparatus is simple, but it is used with such brevity that it pre-supposes that instinct of filling in gaps which only comes with perpetual practice, and should hence be a delight to teachers. What is elementary mathematics is besides a matter difficult to define. Which is, for instance, more elementary, the drawing of a cubic root arithmetically or logarithmically? Where does "school" physics end and the academic variety begin? Professor Haas makes some brief remarks about these things in the preface as a kind of consolation to the intending reader in strict accordance with the etiquette of academic condescension, but the reviewer thinks that to derive a clear insight in the book, you must study it seriously or know the facts beforehand. As a university text-book it is excellent to a degree, when amplified by lectures, but only for serious students of physics and theoretical chemistry, even the ordinary chemist would find that the old story taught in the nineteenth century would serve his purpose better.

Professor Haas gives at the end of the book a short *résumé* in the form of an appendix, which is to be recommended to all who want to know what it is all about. With regard to the modern theories of atoms and quanta in general, they are allowed to co-exist with the luminous ether, left as a vehicle for transmitting light and electro-magnetic radiations, thus relieving one's mind about the continuity of the universe. The innovation that mass depends upon velocity with a simple relationship is, however, a serious thing. This interesting fact has been discovered in connection with the β rays of the radium emanation, but we find that the specific charges of the moving particles decrease as the mass increases, thus leaving the law of conservation of energy intact. There is a delightful hesitation in Professor Haas' treatment of these new notions with explanatory remarks when he thinks the logical mind revolts. He states the case simply and he does it well.

Rotary Converters; Their Principles, Construction and Operation. By E. P. HILL. London: Chapman and Hall, Ltd. Price 25s.

IN view of the fact that the rotary converter is now a very well-known machine, and that a great deal has been published on its design and construction, there may appear to be little justification for a book of this nature. Students and engineers unfamiliar with these machines will, however, find in the volume a mass of information on the construction and testing of modern converters and the fundamental principles governing their operation. Although the design of rotary converters is not actually dealt with, the author considers these machines from practically every other standpoint, and engineers responsible for purchasing, operating and testing this class of machinery should find the book useful. While the commercial rotary converter dates back from the year 1890, it has from time to time undergone various improvements which have simplified its operation and made it a much more satisfactory machine than it was when first introduced. With all the latest improvements, methods of starting and of regulating the voltage, the author deals in a practical manner, and he also considers transformers and auxiliary apparatus. Sub-stations containing rotary converters have recently been made vastly more complicated than they were in the past by the introduction of automatic control gear, which eliminates attendants, and the principles governing this automatic equipment are not generally understood. In the present volume the author makes an attempt to describe the Metropolitan-Vickers automatic control systems and supervisory control system, but the task of tracing out the connections involved is not altogether an easy task. The author has, however, probably described these systems as well as they can be described on paper without the actual apparatus to refer to. An engineer with all the gear before him may derive material assistance from the book, but our own experience is that written descriptions alone of equipment of this nature are by no means easy to follow. Erecting and testing engineers will probably most appreciate the latter chapters of the book, which are devoted to various practical matters, such as erection and starting up on site, mechanical and electrical faults, rotary converter connections, testing and so forth.

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RAILWAY EXPENDITURE IN RELATION TO RAILWAY RECEIPTS.

LAST year the receipts of the four grouped British companies from their railway business experienced a decrease of £27,632,145 as compared with the receipts of 1925. As an offset the companies saved £11,106,550, the economy being effected in every department of the railway and not alone in the maintenance and renewal of way and works, locomotives, carriages and wagons. We should add that the accounts for what we will call the engineering departments—abstracts A, B (1), B (2), and B (3) in the annual report—include, for both 1925 and 1926, sums paid to or received from reserve or suspense accounts.

With the object of showing what those engineering departments did towards economising in the face of such a falling off in business as was experienced last year, we have prepared a table from which have been excluded all contributions from reserves and which gives the actual money paid away in salaries, wages and materials. It ought to be observed that the figures we give for 1926 include no less than £3,004,880 spent out of revenue on new locomotives, carriages and wagons; but it must be remembered that in 1925 the sum so incurred was £3,995,789—the London and North-Eastern spent roughly £1,000,000 less in 1926 and the Southern £500,000 less, whilst the London, Midland and Scottish paid £400,000 more and the Great Western spent £125,000, as against nil in 1925.

The table is fairly self-explanatory. It is intended to show what was saved in each branch of engineering for the railways as a whole and individually, and what each company saved in those branches proportionately to the loss each company experienced in its receipts. Corresponding figures of the traffic expenses are given.

		London, Midland and Scottish.	London and North-Eastern.	Great Western.	Southern.	Four grouped companies.
Receipts from railway business	1925	78,991,113	58,217,639	31,337,441	24,170,294	192,716,487
	1926	67,273,898	48,571,313	26,914,576	22,324,555	165,084,342
Decrease in 1926 below 1925		11,717,215	9,646,326	4,422,865	1,845,739	27,632,145
Ratio of decrease to own receipts in 1925		14·84	16·57	14·11	7·64	14·34
Ratio of decrease to total decrease		42·40	34·91	16·01	6·68	
Expenditure on railway business	1925	64,869,156	50,147,215	25,890,173	19,665,616	160,572,160
	1926	61,047,507	45,646,106	23,636,068	19,135,929	149,465,610
Decrease in 1926 below 1925		3,821,649	4,501,109	2,254,105	529,687	11,106,550
Ratio of decrease to own expenditure in 1925		5·89	8·97	8·71	2·69	6·94
Ratio of decrease to total decrease		34·41	40·52	20·30	4·77	
Maintenance and renewal of way and works, exclusive of contributions to or from reserves	1925	8,759,677	6,652,987	4,513,602	830,761	20,757,027
	1926	7,835,032	5,502,208	3,582,103	885,580	17,804,923
Decrease in 1926 below 1925		924,645	1,150,779	931,499	+54,819	2,952,104
Ratio of decrease to own decrease in receipts		7·89	11·93	21·05	+2·97	10·68
Ratio of decrease to total decrease in way and works expenditure		31·33	38·98	31·55	+1·86	
Maintenance and renewal of locomotives, exclusive of contributions to or from reserves	1925	6,354,616	4,343,751	2,753,844	1,509,936	14,962,147
	1926	5,155,244	3,613,819	2,099,448	1,404,453	12,272,964
Decrease in 1926 below 1925		1,199,372	729,932	654,396	105,483	2,689,183
Ratio of decrease to own decrease in receipts		10·24	7·57	14·80	5·71	9·73
Ratio of decrease to total decrease in locomotive expenditure		44·60	27·14	24·34	3·92	
Maintenance and renewal of carriages, exclusive of contributions to or from reserves	1925	2,479,743	2,930,984	1,499,309	83,135	6,993,171
	1926	3,326,220	2,036,925	1,246,872	85,741	6,695,758
Decrease in 1926 below 1925		+846,477	894,059	252,437	+2,606	297,413
Ratio of decrease to own decrease in receipts		+7·22	9·27	5·71	+0·14	1·07
Ratio of decrease to total decrease in carriage expenditure		+284·61	300·61	84·88	+0·88	
Maintenance and renewal of wagons, exclusive of contributions to or from reserves	1925	3,682,895	4,254,931	1,011,083	45,397	8,994,306
	1926	2,973,194	2,688,596	864,950	41,470	6,568,210
Decrease in 1926 below 1925		709,701	1,566,335	146,133	3,927	2,426,096
Ratio of decrease to own decrease in receipts		6·06	16·24	3·34	0·21	8·78
Ratio of decrease to total decrease in wagon expenditure		29·25	64·56	6·02	0·16	
Maintenance and renewal of way and works, locomotives, carriages and wagons, exclusive of contributions to or from reserves	1925	21,276,931	18,182,653	9,777,838	2,469,229	51,706,651
	1926	19,289,690	13,841,548	7,793,373	2,417,244	43,341,855
Decrease in 1926 below 1925		1,987,241	4,341,105	1,984,465	51,985	8,364,796
Ratio of decrease to own decrease in receipts		16·96	45·03	44·87	2·82	30·65
Ratio of decrease to total decrease in all engineering expenditure		23·75	51·89	23·72	0·62	
Locomotive running expenses, exclusive of fuel—abnormal in price in 1926	1925	9,929,712	7,263,057	3,986,616	2,789,345	23,968,730
	1926	8,742,472	6,196,099	3,277,978	2,819,083	21,036,232
Decrease in 1926 below 1925		1,187,240	1,066,958	708,638	+30,338	2,932,498
Ratio of decrease to own decrease in receipts		10·13	11·06	16·02	+1·64	10·61
Ratio of decrease to total decrease in locomotive running expenses		40·49	36·38	24·16	+1·03	
Traffic expenses	1925	21,875,511	16,306,079	8,356,533	5,836,483	52,374,606
	1926	20,196,885	14,813,903	7,583,322	5,563,852	48,158,052
Decrease in 1926 below 1925		1,678,626	1,492,086	773,211	272,631	4,216,554
Ratio of decrease to own decrease in receipts		14·33	15·47	17·48	14·77	15·26
Ratio of decrease to total decrease in traffic expenses		39·81	35·39	18·34	6·46	

Some Modern Views on the Fatigue of Metals.*

By H. J. GOUGH, M.B.E., B.Sc., Ph.D.

WHILE it should be stated, at the commencement, that no finality of agreed opinion has been reached on the causes of fatigue failure and phenomena, it is significant to find that the trend of modern thought is to associate the failure of metals—whether under static or repeated loading—with the consequences, direct or indirect, of slip, *i.e.*, the process of plastic deformation by shear on gliding surfaces. Attention was first drawn to this aspect of fatigue by the classical researches of Ewing and Humfrey, whose work indicated a line of attack which has been followed up by other investigators, and has resulted in the discovery of important facts. It is to be expected that these facts are not entirely consistent with the conclusions drawn by the earlier investigators from their own work in view of the more refined experimental methods which have since been made available. The pioneer work of Ewing and Humfrey will never be forgotten, however.

THE "ATTRITION THEORY" OF EWING AND HUMFREY.

A study was made of the changes in microstructure of Swedish iron subjected to various ranges of reversed bending stresses. Fatigue fracture was found to result under repetitions of stress ranges of ± 9 to ± 14 tons/inch^2. After a few reversals, slipbands appeared on the surface of the specimen. Under further repetitions of stress other bands appeared, while those first observed became more distinct and appeared to have broadened out. At a later stage they changed into comparatively broad bands, losing their original sharp definition, and covering entire parts of the crystals. At this stage cracking occurred, the cracks following the dark markings and spreading from crystal to crystal until fracture resulted. A range of stress that was regarded as a "safe" range produced only one isolated slip band in the whole of the surface examined. From these experiments Ewing and Humfrey evolved the following theory of fatigue:—

The repeated application of an unsafe range of stress produces deformation by slip, the nature of a slip band being such that, once formed, repeated slipping can occur between the surfaces forming the slip band. This repeated slipping, being of a nature similar to that of solid friction, results in the wearing away of the slipped surfaces by attrition. The resulting attrited matter, or *débris*, is forced to the surface of the specimen and forms heaps on either side of the slipped surfaces. The continued attriting action results in a broadening of the slip band, thus producing a fissure, which spreads from crystal to crystal, leading to failure.

This attrition theory may be said to have held the field until recent years. Let us examine some of the deductions that may fairly be said to attend its acceptance.

(1) A safe range of stress is such as to be insufficient to produce plastic strain; thus, a material cannot achieve an ultimate state of elasticity or freedom from slip under repetitions of a range of stress which causes marked initial plastic deformation. Conversely.

(2) If marked plastic strain results from repetitions of a range of stress that range of stress must produce failure, if applied a sufficiently great number of times.

(3) A gliding surface, having once slipped, is weakened (as regards resistance to further slip) by the process.

These points, it is suggested, afford a fair basis for further inquiry. It will be seen that attention is at once directed to the stress-strain relations, *i.e.*, the state of elasticity, associated with a metal subjected to repeated stresses.

BAUSCHINGER'S THEORY OF THE "NATURAL RANGE OF ELASTIC LIMITS."

In 1881 Bauschinger showed that the "primitive" or initial state of elasticity of a metal could be profoundly modified by cyclical variations of stress. The primitive elastic limits were raised or lowered by such variations—not necessarily by the same amount—and new limits were produced. The range of the ultimate or "natural" limits acquired were assumed to correspond to the limiting range of stress. The value of this range depended partly on the value of the mean stress of the cycle. It is important to note that Bauschinger emphasised the achievement of an ultimate state of elasticity after the metal had suffered permanent deformation. In 1910 Bairstow took up this subject, and using more accurate equipment, substantiated the truth of Bauschinger's theory of the range of natural elastic limits. He investigated very fully the elasticity of iron and steel under cyclical variations of stress. His work is so well known that it is only necessary to state his conclusions in the form of two very general cases which bear on the points now under consideration.

(1) *Stress-Strain Relations Under a Safe Range. (General Case.)*—Permanent deformation may result during the first cycle of loading. The type of stress-strain curve obtained resembles the magnetic "hysteresis" loop, strain lag being present. The loop is not entirely closed. During subsequent cycles, permanent deformation occurs at a decreasing rate, the width of the hysteresis loop also diminishing. Finally, a condition is reached when no further permanent deformation occurs, while the hysteresis loop is apparently entirely closed, denoting perfect elasticity. (The "recovery" of elasticity under cycles of a safe range of stress is very important.)

(2) *Stress-Strain Relations Under an Unsafe Range of Stress. (General Case.)*—An unclosed hysteresis loop is first recorded, with permanent set. Under subsequent cycles one of two general phenomena may be observed:—(*a*) The rate of increase of permanent set and of the width of the hysteresis loop may decrease at first, be reduced to a very small value indeed, and increase rapidly in the later stages when fracture is imminent; or (*b*) the rate of increase may increase at first, then attain a constant value (sometimes zero) before increasing rapidly in the final stages.

Condition (*a*) is particularly important as it indicates an attempt to obtain elastic conditions even under an unsafe range of stress.

Now the marked initial deformation observed by Bairstow to occur under a safe range of stress must have been accompanied by the formation of slip bands. Unfortunately, Bairstow did not study changes in the microstructure of his specimens. To obtain some evidence on plastic deformation under safe ranges of a different type of stress, the author investigated the elastic limits of copper under reversed bending stresses. Copper of a high degree of purity was selected, as preliminary tests showed that this metal was so soft as to possess no clearly defined primitive elastic limit or yield point. The results obtained were similar to those of Bairstow. Under safe ranges of stress large unclosed hysteresis loops first appeared. With subsequent reversals these loops disappeared, the material attaining almost perfect elasticity. When the fatigue range was exceeded large unclosed loops

* Paper read before the Institution of Structural Engineers, February 10th, 1927.

appeared which diminished in width until a minimum value was reached, this being maintained until the stage immediately preceding fracture was reached.

Quasi-Elasticity or "Elastic Hysteresis."

It is important to determine if a metal, having suffered permanent strain under cycles of a safe range of stress, and such permanent strain having ceased to be produced, ever attains a state of perfect elasticity, that is to say, if the width of the hysteresis loop becomes zero. Two methods of investigation are available :—(*a*) The direct method of tracing the stress-strain relations during a cycle of loading by means of a very accurate strain meter; and (*b*) by the use of a sensitive heat-recorder, such as a multiple thermo-couple or calorimeter attached to the specimen; the principle of this latter method being that if a loop of definite width exists, its area represents an amount of energy abstracted every cycle from the external straining forces, which if not spent in producing permanent deformation of the material or increasing the internal energy of the material reappears in the form of heat. Experiments on one or both of these lines have been carried out by many investigators, including Guest and Lea, Hopkinson and Williams, Rowett, Hankins, Haigh, and the author. It is now generally accepted that following overstrain, recovery under alternating stress produces conditions which are not truly elastic although cumulative permanent set does not occur. The term "elastic hysteresis" has been applied to this state of quasi-elasticity. The actual shape of the corresponding stress-strain curve is a loop symmetrical about the mean stress of the cycle. Elastic hysteresis thus represents an action—probably interatomic—which is mechanically but not thermo-dynamically reversible; it is probably caused by internal local strains and/or is due to some indirect consequence of previous plastic strain.

FIG. 1—Armco Iron after 12,000,000 Reversals of a Safe Range of Stress

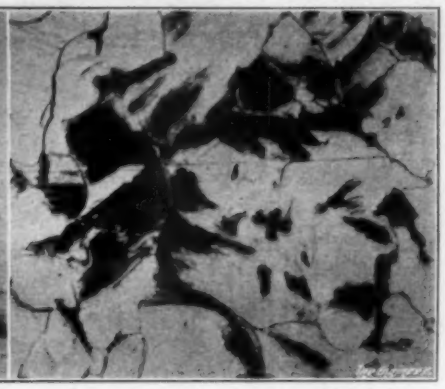


FIG. 2—Mild Steel after 10,000,000 Reversals of a Safe Range of Stress

The Effect of Slip Caused by Stress Concentrations.

Some quantitative data regarding the effect of slip may be derived from experiments on specimens containing discontinuities of section. Such discontinuities in materials subjected to straining actions produce stress concentrations which have been investigated mathematically by Suyehiro, Inglis and others. The mathematical laws involved assume elastic isotropic and homogeneous material. That, under these conditions, the calculated stress concentrations actually occur has been verified by the photo-elastic methods of Coker and the soap-bubble method of Taylor and Griffiths. Engineering materials are not homogeneous nor isotropic, but provided the elastic limit is not exceeded, the required assumptions are approximately fulfilled. Let us take two metals, A, a very soft, and B, a much harder metal. Introduce into the section of specimens of these metals a discontinuity of such a shape as to produce a stress concentration of value N. Then, the elastic limit (statical) and the fatigue range of both metals would, in presence of these discontinuities, be expected to be reduced to $1/n^{th}$ of their original value if the initiation of slip is sufficient to bring about fatigue fracture. Experimental evidence on this point is available. The author employed round shafts of a soft iron and, also, a medium carbon steel. The elastic limit in static torsion, also the fatigue range under reversed torsional stresses was determined for both materials. Accurately machined keyways were then cut in other samples and the same quantities determined. It was found that the elastic limits were reduced, for both metals, by the same amount, namely, 23 per cent. This value agreed exactly with the calculated stress concentration effect. But the fatigue range of the softer material was reduced only by 12 per cent. due to the presence of the keyway, while that of the harder steel was reduced by 21 per cent. Again, using a plain high carbon steel which had been subjected to a great degree of cold rolling—its ductility was practically exhausted—the author found that the presence of a round hole reduced the fatigue range, under repeated tensile loading, to $\frac{1}{2 \cdot 7}$ of its original value, as compared with the value of $\frac{1}{3}$ as predicted by the mathematical laws of elasticity. Again, Haigh found that the presence of a circular hole in specimens of mild steel had very little effect on the value of the fatigue range, whereas small circular holes in hard drawn steel produced an actual concentration effect of 2·15 as compared with the theoretical effect of 3. The conclusion drawn from these and similar experiments is that the full theoretical stress concentration effect is set up, producing failure of elasticity; such failure having occurred, however, there is a degree of insurance against fatigue failure or fracture which is proportional to the capacity of the metal to deform plastically by slip. This may mean, either, that—

(1) Slip is an essentially strengthening action as regards resistance to further deformation; or

(2) Slip may be, in itself, a weakening action, but it produces a more favourable redistribution of stress (stress-concentration effects are very local); or

(3) Slip is a strengthening action in itself and is also the means of producing a more uniform redistribution of stress.

There is a great deal of general evidence indicating that conclusions Nos. 1 and 3 are correct. Nevertheless as calculations of stress on a cross-section of a metal consisting of a finely-divided aggregate are only approximate, it was not until specimens consisting entirely of one single crystal were available that the truth of conclusion No. 1 was demonstrated beyond all doubt. This will be referred to later.

More Detailed Examination of the Effects of Static and Repeated Stresses on the Microstructure of Metals.

A consideration of some of the foregoing experimental data led the writer to form a vague opinion that slip was essentially a strengthening process but that failure was, in some unknown way, an indirect consequence of slip. It appeared necessary to make a much more detailed examination of the effects of slip on the microstructure of metals than had hitherto been attempted. Dr.—now Professor—Hanson was approached and agreed to co-operate in a research of this nature. The work was of a very comprehensive nature and the most significant observations only can be mentioned here. They may be summarised as follows :—

(1) Slip bands in great profusion were caused by safe ranges of stress. This applied to all the metals examined (Armco iron, steels, copper) under all types of stressing actions employed (reversed direct, bending and torsional stresses). See Figs. 1 and 2.

(2) No marked differences were observed in the nature of the slip bands caused by safe or unsafe ranges of stress. Broad dark bands, presumably similar to those observed by Ewing and Humfrey, were found; in many cases, however, these bands could be resolved, at high magnification, into masses of very fine slip bands; these bands did not seem to be crevasses or cracks, although the cracks ultimately causing failure appeared to originate in these regions.

(3) Slipping was not confined to those areas where slip bands were first produced; with subsequent reversals of stress, other slip bands appeared in the neighbourhood of, or at places removed from, these initial slip bands.

(4) Under repetition of an unsafe range of stress, the cracks causing failure, appeared to originate in the areas of heavy slip, but spread through regions which were free from slip. The action was similar to that obtained by driving a sharp wedge through hitherto undistorted areas; thus the spreading of the crack was due to stress concentration effects set up at its end, a process fundamentally different from that of fatigue in its earlier stages before the crack was formed. See Figs. 3 and 4.

(5) A state of "elastic-hysteresis" resulted from repetitions of a safe range of stress.

FIG. 3—Fatigue Crack in Armco Iron

FIG. 4—End of Crack shown in Fig. 3

From a detailed consideration of the observations, a theory of strain-hardening was deduced, some aspects of which are stated below.

Theory of Strain-Hardening Governing the Behaviour of Metals Under Static and Repeated Stresses. (Gough and Hanson.)

Under the application of a certain load plastic yielding will occur in certain crystals on planes favourably situated. The material in the neighbourhood of the slip plane is immediately strain-hardened offering increased resistance to further slip. On removal or reversal of the load a state of stress is set up in other regions of the crystal, causing further slip, but in the reversed direction to the original slip. With subsequent cycles of stress further stress-redistribution is brought about, accompanied by an increase in the number of slip bands, and a general hardening of the metal is accomplished. (The action may be considered analogous to a ratchet and pawl action.) The metal tends to attain a cyclic state, *i.e.*, to develop a hysteresis loop symmetrical about the mean stress of the cycle, whatever the value of the mean stress may be. The total permanent deformation of the metal as a whole under safe stress ranges will thus be largely dependent on the value of the maximum stress of the cycle of loading, while the amount of relative dislocation of neighbouring crystal planes within a crystal will be dependent mainly on the value of the range of stress.†

Should the applied range be a safe range, at some stage, further permanent deformation will not occur, and if the surface of the specimen be re-polished, subsequent repetitions of the same range of stress will not produce slip bands. The metal will then be harder than in the original condition. As a consequence of the slip that has occurred, the crystal will be in a state of internal stress, and will exhibit stress-strain relations possessing "elastic hysteresis." Should the applied range of stress exceed the fatigue range, the action is similar to the above, with one important exception. Stress-redistribution will occur, with the production of slip bands, resulting in a hardening of the crystal as a whole. Plastic strain, however, will never entirely cease, although the rate of increase of set may vary widely during a test. Now, as far as the hardening effects of slip are concerned, this continued plastic strain would tend to produce a progressive hardening. But such hardening is produced at the expense of the production of severe local stresses at the slipped surfaces or in their neighbourhood.

At some stage these stresses will attain such local magnitudes as to produce disruption of the bonding between neighbouring atoms. An unsafe range of stress is such as to render this a cumulative action with the formation of sub-microscopic cracks of such a shape—the dimensions are relatively unimportant—as to create great stress concentrations, thus serving to propagate these cracks throughout the metal and causing total failure.

Particular attention is drawn to the distinction made between the direct effect of slip as an essentially hardening process on the metal as a whole, and its indirect consequence of setting up such local dislocations or stresses as to lead to the formation of cracks. That the cracks do eventually form in slipped regions is beyond dispute. With regard to the important prediction that hardening by slip should result both under safe and unsafe ranges of stress, independent evidence is now available. Dr. Aitchison, in order to investigate this point of our theory, examined the hardness of specimens of fine steels, two brasses, and copper, some of which had been tested under safe ranges of stress, others having been broken under unsafe ranges. He made Brinell hardness tests on two places in each specimen :—(*a*) In the central stressed portion; and (*b*) in the end where the stressing had been very slight. The following extracts are taken from his paper :—

. . . "From the results it follows that the application of fatigue stresses to metals results in hardening which may be just as great as that resulting from the application of very considerable static stresses. . . . Presumably it is the effect of the internal slipping observed to occur by

† When a crystalline aggregate is stressed, as a whole, isolated crystals will suffer more severely than others. This is due to the particular orientation of these crystals being more favourably disposed to slip because of their relative crystallographic orientation to the axis of loading. It does not imply that these crystals are necessarily weaker than their neighbours, or that they differ in nature, although, of course, the latter may be true in the case of a duplex or more complex structure.

Gough and Hanson. This slipping must be regarded as plastic strain in relation to fatigue stress. . . . The operation of fatiguing a metal is in reality a process of cold working, and the fatigue limit is the highest stress which does not produce cumulative plastic strain (in the fatigue sense) within the crystal. . . . The fatigue strength of a material is purely and simply controlled by its capacity for cold working." Two further predictions afforded by the theory have received experimental confirmation. If a specimen is cold-worked by many repetitions of a safe range of stress its fatigue strength, and, also, its statical strength, should be increased. The author has shown that the fatigue strength of a low carbon steel can be raised 28 per cent. by such understressing treatment. Moore and Jasper have found that the statical tensile strength of metals may be increased by varying amounts up to 20 per cent. of their original value by subjection to cycles of reversed direct stresses.

But there remained many outstanding points and problems which could not be investigated by a study of crystalline aggregates, and attention was then directed to the fatigue properties of specimens consisting entirely of one large crystal. In such specimens, with the atoms arranged in a regular continuous system throughout, the positions of the crystal planes, with relation to the axis of loading, can be determined, with great precision, by X-ray analysis. Special methods were devised, by means of which changes of microstructure could be related to the crystallographic planes. The changes in microstructure, deformation and fracture of single crystals of aluminium subjected to:—(*a*) Reversed direct stresses; (*b*) reversed torsional stresses; and (*c*) single blow impact-tensile stresses were investigated, also the stress-strain relations under slow cyclical repetitions of tensile stress were examined. Under all these types of straining actions, it was found that deformation occurred with the formation of slip bands. These slip bands were identified as the traces of the actual slip planes on the surface of the specimen—see Fig. 5. The slip planes were shown to agree with the octahedral planes of the crystal. (These octahedral planes are, in the case of aluminium, the planes of greatest density of atomic packing.) On an octahedral plane, the principal lines of atoms are three in number, forming the sides of an equilateral triangle. Thus, on the four sets of octahedral planes existing in the crystal, there are twelve directions of these principal lines of atoms. It was found that the slip bands produced—whether under statical, fatigue or impact straining—corresponded to deformation by shear on an octahedral plane containing that line of atoms on which the resolved shear stress was a maximum. The theoretical aspects of the work, with which we are chiefly concerned, confirmed the earlier strain-hardening theory and enabled it to be carried to a more fundamental stage.

That slip is essentially a hardening process was clearly established without doubt or question.

The stress analysis showed definitely that the intensity of slip on a slip plane increased as slipping proceeded. Yet the action was self-stopping. Thus, during a fatigue test where slipping occurs, the hardening effect must proceed at a greater rate than the slip itself, or else the specimen would fail immediately slip commenced. Yet slip bands were produced in great profusion under very small ranges of stress, which were only a fractional part of the limiting range. It was shown that the material on a slip plane was so much harder than the original material that the site of a previous slip band was disclosed by mere polishing alone, without etching. (This discovery was invaluable to us in determining the complex nature of the distortion of a crystal subjected to torsional straining.) By very small ball indentations on the cross-section of a torsion test piece, it was shown that the amount of hardening was, roughly, proportional to the amount of the range of stress previously applied, irrespective of whether that range was safe or unsafe. The manner in which growth of slip bands occurred was precisely similar to that previously observed in crystalline aggregates. Under a safe range of stress producing initial permanent distortion, a state of elastic hysteresis was found to exist, a symmetrical loop being obtained. Fracture occurred by cracking in the most highly stressed part of the crystal, the initial direction of the cracks coinciding with that of the slip bands—see Fig. 6. A very important observation made was that the process of hardening on one set of planes produced a general hardening on other sets of planes—not parallel—in their neighbourhood; thus slip produces a progressive and general hardening. Now with regard to the very important point that cracking and the propagation of the crack is an indirect consequence of slip and need not, therefore, be necessarily accompanied by slip, a critical experiment was successfully made. A specimen was subjected to such a range of reversed torsional stresses as to produce a very lengthy endurance. It withstood 9,275,000 reversals before fracturing. The surface of the specimen was repolished at six stages during the test and examined and photographed at each stage. It was repolished for the last time after 7,204,000 reversals. After fracture, a careful examination failed to reveal any slip bands in the neighbourhood of the fracture. Thus, during the preceding 7¼ million reversals the crystal structure had been strain-hardened to its fullest extent, and refused to slip any more under the same range of stress. But in the process of strain-hardening, an indirect consequence of the slip had been to produce small local disruptions of such an order of magnitude that they became slowly accumulative and spread causing complete failure.

It is submitted that the single crystal experiments had confirmed, in a very satisfactory manner, the main principles of the "strain-hardening" theory of fatigue deduced from a study of crystalline aggregates.

Two very important points remain, however, on which it is very hard to obtain experimental evidence, and which are still largely speculative, although a certain amount of circumstantial evidence has been obtained by a number of investigators working quite independently. First, what is the actual mechanism of hardening on the slip plane, and, secondly, what is the precise manner in which the fatigue or static crack is first formed? I suggest the following explanations and submit various corroborative evidence in support. When slip occurs on a certain set of planes in a certain direction, the slip plane becomes buckled or rumpled in the direction of the slip. The average curvature of the slip plane is still zero; if this were not the case, X-ray analyses made at different parts of the crystal would not agree with that of a single crystal. In the earlier stages of slip—small deformations—the amount of the local bucklings is probably very small. But it is sufficient to harden the material against further slip under the same, or even a slightly greater load than that previously applied. It also involves local residual stresses. As the deformation proceeds in intensity, the degree of buckling increases. The limiting strain of the inter-atomic bonds being very small, at some stage—probably quite early—the main crystal breaks up into a great number of smaller crystallites, each probably a perfect single crystal, the orientation of such crystallites varying only slightly from that of the original crystal structure. The hardening effected is thus a measure of the severity of the previously applied strain. For evidence on this point it is necessary to turn to the interpretation of X-ray photographs of strained and unstrained material. An unstrained crystal gives clearly defined X-ray reflections. A distortion of the type indicated above would be expected to give broadened X-ray reflections. This change in the nature of the reflections was observed in some of the crystals used in our researches. Similar changes were noted by Taylor and Elam from aluminium crystals after static tensile straining, by Owen and Preston from aluminium aggregates after severe cold working, by Goucher from tungsten single crystals after tensile straining, by Smithells, Rooksby and Pitken from tungsten after gauging and drawing. Further, Goucher has shown that this broadening occurs only in the direction of slip and not in the perpendicular direction. Under severe tensile loading this broadening is so pronounced that if it were due to elastic straining of the lattice, the lattice parameter would be altered to such an extent as to be easily distinguishable by X-ray measurements. Yet the experimental data of Goucher, also Owen and Preston, entirely fail to show any such distortion. There appears, therefore, to exist indisputable evidence that strain-hardening is caused by crystal break-up into a number of smaller, very perfect—structurally—crystallites. Of the mechanism by which these crystallites rotate into their new positions, nothing is known. The actual hardening is effected by the slip inhibition due to the differences in orientation of neighbouring crystallites. If the attainment of strain-hardening by crystal break-up is accepted, it appears logical to deduce that the origin of the submicroscopic cracks lies in the boundary regions between

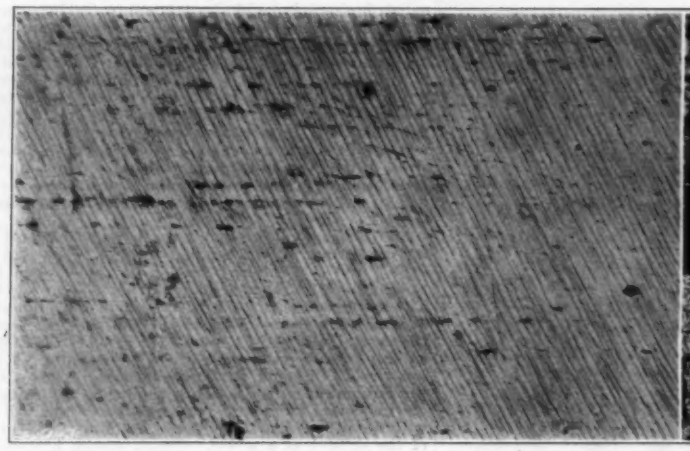


FIG. 5—Slip Bands in Single Crystal of Aluminium Caused by Repetitions of a Safe Range of Stress

FIG. 6—Single Crystal of Aluminium Fractured under Reversed Torsional Stress

FIG. 7—A Typical Fatigue Fracture

these crystallites. If it be considered that at these boundaries simple disruption of atomic bonding occurs, then the propagation of the cracks under a sufficient range of stress can be ascribed to stress concentration effects alone. On the other hand, such disruption may produce phase change of the type suggested by Beilby. Such a phase change would be accompanied by a change in density which might set up sufficient internal stresses as to be amply sufficient to produce a cracked structure. At the present time, evidence on this point is conflicting. Farren and Taylor have found that plastic deformation of metals is accompanied by a definite increase in internal energy. This is consistent with phase change. On the other hand, very careful measurements of the density of single aluminium crystals before and after fatigue stressing showed no change in density exceeding the order of accuracy of the measuremnets—1 part in 3000. Owen and Preston obtained a similar result in density tests on aluminium before and after severe cold rolling. Future researches will no doubt clear up this point.

In Fig. 7 a typical fatigue fracture is illustrated. The specimen was a shaft 9in. in diameter, and failed under repeated torsional stress. Attention should be given to the outer zone caused by the spreading fatigue cracks and the central core which failed suddenly at a later stage.

In conclusion, it is submitted that the strain-hardening theory of fatigue is worthy of consideration. It is simple to understand, and is consistent with the most recent experimental data. It may be simply expressed by the statement that the fracture of metals is an indirect consequence of slip which in itself is essentially a hardening process. The theory is not fundamental, and should not be so regarded, and will, no doubt, be amplified or replaced. In the meantime, however, if it affords a working hypothesis for engineers and others, and also stimulates further research, it will have served a useful purpose.

Cooling and Cleaning Plant at Scunthorpe Gasworks.

AN unusual type of gas cooling and cleaning plant has been installed at Scunthorpe gasworks in which, instead of the normal routine adopted for these processes, the gas from the generators passes through a hydraulic seal into a gas-collecting main and from there direct to a Lymn cooler and cleaner—as shown in Fig. 1. This is a static gas washer which has been used for some years on producer gas, though the Scunthorpe installation provides the first instance of its adoption for town gas cleaning purposes.

The Lymn cooler and cleaner installed at Scunthorpe operates on the principle of utilising the momentum of the upward flow of gas, sent in at the bottom of the cooling tower to atomise liquid falling in thin sheets, admitted at the top of the tower, with the resultant intimate contact between gases and liquid without the use of any mechanical spraying device or any other moving parts.

The cleaner consists of a cylindrical casing of mild steel, fitted with top and bottom plates, gas inlet and liquid outlet at the bottom, and with gas outlet and liquid inlet at the top. A vertical stationary shaft is fitted in the centre of the apparatus, extending the height of the casing. At suitable distances from each other a series of discs or distributing devices for the liquid is fixed on the central shaft, and attached to the casing is a corresponding series of inverted truncated cones which serve as collecting devices, the design of these internal parts being varied to suit particular requirements.

Falling by gravity alternately from distributors to collectors and *vice versâ*, the thin sheets of liquid are atomised, and fall in the form of a fine spray—itself flowing in a zigzag path in the opposite direction—on to the collectors and distributors, where the spray again forms into thin sheets of descending liquid. Each particle of gas is thus brought into contact with the liquid many times before it leaves the apparatus.

On leaving the Lymn washer the gas enters a centrifugal gas exhauster, in which the last traces of tar are removed by the addition of a small quantity of water, which is atomised by the exhauster impellers. The hot cooling water from the washer and the exhauster is passed into a concrete tank, where the tar separates out and is pumped to storage. The hot water is re-cooled by passing it over a water-cooling tower, whence it is returned to the washer for re-use. The gas is then passed into the purifiers in the ordinary way.

In the Scunthorpe plant no ammonia is being recovered, but the present plant is so laid out that an ammonia absorber can be placed between the hydraulic main and the cooling and cleaning plant, using the Power Gas Corporation absorber—shown in Fig. 2—in which the ammonia is absorbed by washing the gas direct with a dilute sulphuric acid solution, as is customary in Mond gas plants.

It is claimed that the Scunthorpe plant is more simple, and cheaper in first and maintenance costs than the elaborate plant usually employed for the indirect system of cooling and cleaning town gas. Particulars giving the capital and maintenance charges for a plant to deal with 5 million cubic feet of gas and 500,000 cubic feet of gas per day respectively are appended.

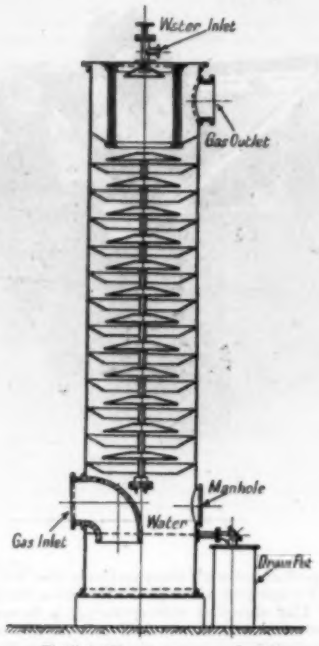


FIG. 2—AMMONIA ABSORBER

Capital cost of gas cooling plant, including cooler, exhausters, pumps and water-cooling tower to deal with 5 million cubic feet of gas per twenty-four hours would be approximately £2600.

Power required: Gas exhausters, 35 horse-power; pumps for gas cooler and water coolers, two at 8 horse-power.

Labour: 1 man (part time) attending to tar removal; 1 man (part time) attending to machinery.

Sulphate of ammonia absorbing and evaporating plant for the above would cost about £3500.

Capital cost of gas cooling plant, including cooler, exhauster, pumps and water-cooling tower to deal with 500,000 cubic feet of gas per twenty-four hours would be about £1450.

Power required: Gas exhauster, 10 horse-power; pumps for gas cooler and water cooler, two at 1½ horse-power.

Labour: 1 man (part time) attending to tar removal; 1 man (part time) attending to machinery.

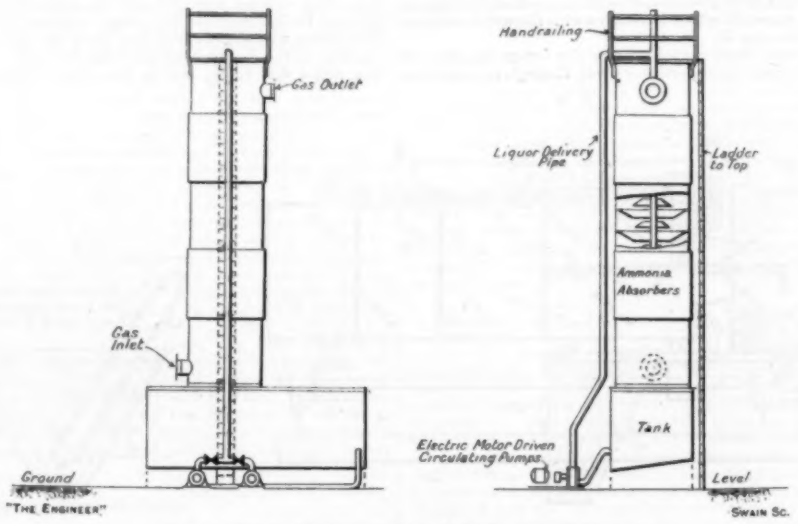


FIG. 1—THE LYMN STATIC GAS COOLER AND CLEANER

CONFERENCES ON INDUSTRIAL WELFARE.

THE Industrial Welfare Society has arranged two Conferences to be held at the Hotel Victoria, Northumberland-avenue, the first on Thursday, May 12th, and the second on Thursday, May 19th. At the first session, on the 12th, which will start at 11.15 a.m., the subject to be discussed is "Works and Staff Committees," the introducer being Mr. E. J. Fox, managing director of the Stanton Ironworks Company, Ltd. At the afternoon session, which will open at 2.30 p.m., the subject of discussion is to be "Suggestion Schemes," and the opening speaker will be Mr. Geoffrey le M. Mander, managing director of Mander Brothers, Ltd.

At the second Conference on May 19th, which will open at 11.15 a.m., the subject is to be "Pension Funds," and it will be introduced by Sir Joseph Burn, K.B.E. In the afternoon at 2.30 p.m. Mr. Leonard J. King, of Angus Watson and Co., Ltd., will open a discussion on "Sickness and Benevolent Funds."

Further particulars regarding these Conferences may be obtained on application to the secretary, the Industrial Welfare Society, 51, Palace-street, S.W. 1.

Catalogues.

BARLOW AND CHIDLAW, Ltd., Pendleton, Manchester.—Tables of gear tooth parts.

CROMPTON AND CO., Ltd., Chelmsford.—Descriptive list No. 81 of generating plant of various types.

GENT AND CO., Ltd., Faraday Works, Leicester.—Electric watchman's tell-tale clock catalogue.

SAMUEL OSBORN AND CO., Ltd., Sheffield.—A record of the growth of the firm from 1852 to 1927.

JOHN HOLROYD AND CO., Ltd., Milnrow.—Booklet entitled "Machine Tools to Increase Production."

CAMPBELLS AND HUNTER, Ltd., Leeds.—Catalogue 9/27 dealing with railway wheel lathes for heavy duty.

W. N. BAINES AND CO., Ltd., Rotherham.—A 120-page catalogue of engine and boiler fittings of all types.

THE ELECTRIC FURNACE COMPANY, Ltd., 17, Victoria-street, S.W. 1.—Pamphlet D 2 on electric resistance furnaces.

CECIL HODGES AND CO., Ltd., Empire Works, Dalston.—Folders 127 and 128 illustrating the "Empire" pump.

MAWDSLEYS, Ltd., Dursley, Glos.—Illustrated booklet of direct-current dynamos and motors, binary converters, &c.

THE GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, W.C. 2.—Booklet X4156 on ironclad switchgear.

BOLCKOW, VAUGHAN AND CO., Ltd., Middlesbrough.—Booklet giving lists of the sizes and types of steel supplied by the firm.

F. S. MURDOCK AND CO., Ltd., Belfast.—Leaflets describing various lifting and stacking machines and illustrating their use.

E. J. AND J. PEARSON, Ltd., Stourbridge.—Booklet giving particulars of fire-bricks of all shapes and sizes and for all purposes.

ELECTRO CHEMICAL PAINT COMPANY, Ltd., 12, Eagle-street, W.C. 1.—Leaflet giving particulars of "Subox" permanent lead paint.

THE WESTINGHOUSE BRAKE AND SAXBY SIGNAL COMPANY, Ltd., 82, York-road, N. 1.—Particulars of R.E.C. mechanical signal fittings.

JOSEPH STEPHENSON AND CO., 83, Queen Victoria-street, E.C. 4.—Detailed description of the "Hades" combination oil or gas burners.

WARREN BROTHERS (Middlesbrough), Ltd., Grange-road West, Middlesbrough.—Leaflet describing "Howards" patented steam separator.

MIRRLEES WATSON COMPANY, Ltd., Scotland-street, Glasgow.—Catalogue No. 810, illustrating and describing in detail cane crushers and mills.

LEISTIKOW, ALLISON AND LYON, 18, Southampton-buildings, W.C. 2.—Leaflet No. 21, describing the new Krupp high-speed "Widia" tool steel.

RANSOME AND MARLES BEARING COMPANY, Ltd., Newark-on-Trent.—List of a complete range of self-aligning double-row ball journal bearings.

SIR HOWARD GRUBB, PARSONS AND CO., Walker Gate, Newcastle-on-Tyne.—Publication No. 4, containing illustrated lists of optical instruments.

BROOK MOTORS, Ltd., Empress Works, Huddersfield.—List No. 153 of single, two, and three-phase motors in ratings from one to 95 horse-power.

H. SPENCER AND SON, "Greencroft," Radcliffe New-road, Whitefield.—Description of a patented flue expansion joint for back of boiler appliances.

RILEY POWER EQUIPMENT COMPANY, 49, East Wells-street, Milwaukee, Wis., U.S.A.—Leaflet on the "Eckenroth" automatic reseating blow-off valve.

LEHMANN, ARCHER AND CO., Ltd., 5, Farringdon-road, E.C.—Brochure entitled "The Choice of Experience," dealing with the origin of the B.A. screw thread.

DOUGLAS, LAWSON AND CO., Ltd., Birstall, Leeds.—Catalogue with sections in French, Spanish and Portuguese, giving particulars of wrought iron pulleys.

BUDENBERG GAUGE COMPANY, Ltd., Broadheath, near Manchester.—Catalogue Section 3 of pressure gauge testers, depth gauges, mercurial vacuum gauges, &c.

J. WILLOUGHBY AND SONS, 10, Cedar-grove, Mount-street, Batley.—Leaflet describing "Willoughby's" improved patented steam regulating valve and circulator.

THE CORK MANUFACTURING COMPANY, Ltd., South Chingford, E. 4.—Booklet giving a full description of "Langite," a soft jointing material, and the uses to which it can be put.

THE TUNGSTONE ACCUMULATOR COMPANY, Ltd., 3, St. Bride's House, Salisbury-square, E.C. 4.—Folder giving particulars of the construction of the "Tungstone" accumulator.

B. AND S. MASSEY, Ltd., Openshaw, Manchester.—Catalogue 3030 H, giving particulars of machines for railway work, including special hammers, machines for the smithy, forge, &c.

NORRIS, HENTY AND GARDNERS, Ltd., Patricroft, Manchester.—Supplement to the T type engine catalogue No. 505, which shows several new features recently embodied in the T type oil engine.

THE DRAYTON REGULATOR AND INSTRUMENT COMPANY, Ltd., West Drayton, Middlesex.—Pamphlets on the "Drayton" automatic de-superheater or attemperator, and the "Union" combustion recorder.

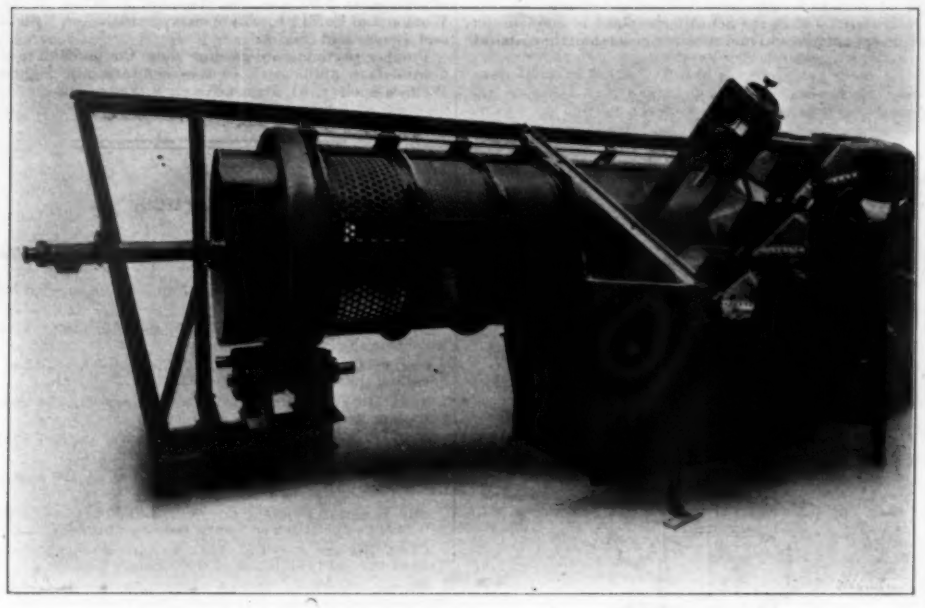
ALLEN LIVERSIDGE, Ltd., Victoria Station House, S.W. 1.—Brochure entitled "All's Well that's Welded," dealing with acetylene and electric welding in the manufacture and repair of road transport vehicles.

THE PREMIER ELECTRIC WELDING COMPANY, Ltd., Abbey Wood, S.E. 2.—The "Premier" handbook for electric welders and a booklet by J. H. Paterson, entitled "Thermal Disturbance in Iron and Steel During Welding."

THE CHURCHILL MACHINE TOOL COMPANY, Ltd., Broadheath, near Manchester.—Booklet of Churchill grinding machines as applied to locomotive maintenance and manufacture, also pamphlet V.N.V. 5, dealing with universal grinding machines.

GRAVEL WASHER AND SCREENER

HARDY AND PADMORE LTD., WORCESTER, ENGINEERS



A New Gravel Washer.

A new type of gravel washer and screener has recently been introduced by Hardy and Padmore, Ltd., of Worcester. A view of the machine is given in the accompanying half-tone engraving, while its construction is shown diagrammatically in the drawing.

The gravel is fed into the hopper A at regular intervals. The makers themselves suggest that the best results will probably be achieved if the dirty material be supplied to the machine at the rate of one six-hundredth part of the total weight that the machine is designed to treat per hour, every six seconds. The hopper is furnished near its top with a grating to prevent large stones from passing into the machine. The discharge from the shoot of the hopper is into B, the first of three revolving conically-shaped drums or barrels through which a stream of water is continually passed in a manner that will be explained later. The conical shape of the barrel does away with the necessity for internal blading, for it allows the gravel to pass gradually and regularly to the far end, meeting the stream of water and being partially washed on the way. Incidentally, as the makers point out, an advantage of using their patented arrangement of conical barrels is that conical barrels can be revolved twice as fast as can parallel barrels. If the latter be run at above a certain speed, their internal blading exerts such a propelling force on the water that its flow is interfered with, whereas, conical barrels, since they have no internal blading, can be run twice as fast and give a correspondingly increased output.

At the far end of the barrel B the gravel is picked up by lifting shelves C, which, as each in turn reaches the top of its travel, discharge it on to a transfer shoot D, which delivers it into the next barrel E, where further washing takes place with cleaner water. At the far end of E, the partially washed gravel is picked up by lifting shelves F and delivered by means of the shoot G into the third barrel H, where still further washing takes place with practically clean water. It may here be explained that in one form of the apparatus—that shown in the drawing—the clean washing water enters through the pipe J into the barrel H, and flows from the latter into barrels E and B in turn, finally running to waste from the last named at the feeding hopper end. It will be noticed that the water level in H is kept higher than that in E, and that the latter is higher than that in B, so that there is always a head of water between two adjacent barrels.

The practically clean gravel when it reaches the far end of the barrel H is lifted by shelves K and sent down the shoot L into the revolving barrel screen M, which is a cylinder perforated with comparatively fine holes. There the gravel is sprayed with clean water from the perforated pipe N. The object of this spraying is to remove the coating of sand which may still adhere to the particles of gravel, despite the triple washing in the three barrels that they have already received. The sand thus removed passes down with the water through the holes in the barrel screen M into the separator O at the bottom of which it is deposited and from which it is removed by a bucket elevator P and discharged at the side of the washer. The separator is divided into two compartments, by a plate Q, which is taken down nearly to the bottom, and the object of which is to prevent the whole of the water being unduly agitated by the action of the elevator. The water in the left-hand division being comparatively still, the sand settles down, and, passing between the lower edge of the plate Q and the sloping bottom of the separator casing, finds its way into the boot of the elevator.

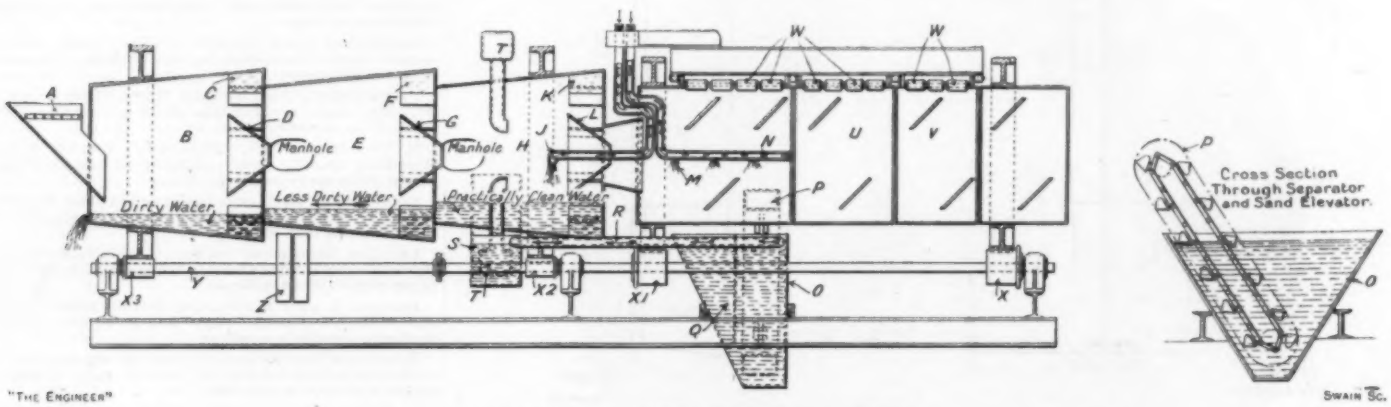
The water overflowing from the separator O flows along a channel R to a tank S into which dips a series of arms provided with lifting buckets T, which raise it and discharge it into the barrel H, where it mingles with the water arriving through the pipe J.

It will have been gathered from the foregoing that the further the gravel proceeds on its way through the machine, the cleaner is the water it meets and the cleaner it, itself, becomes.

The separator is not fitted to all Messrs. Hardy and Padmore's washers, but when it is—as shown in our illustrations—the makers suggest that, as an alternative, the supply of water through the pipe J may be dispensed with, and the whole quantity provided through the pipe N.

The washed and sand-freed gravel passes from the screen M to further screens U and V, or more if desired; the apertures in which are proportioned to give the required grading of the gravel, and which are furnished with inclined blades to facilitate the passage of the gravel towards the end of the machine where the stones that are too large to pass through the largest holes in the screens are discharged. The screen barrels are provided with a series of rollers W, which are hung on swinging links, and the object of which is to hammer out of the holes in the screens any pebbles that may have wedged themselves into the perforations. This arrangement, it is claimed, saves much time and trouble besides securing the full efficiency of the screens.

The washing barrel portion of the machine revolves independently of the screen portion. Both portions are embraced by turned rollers that rest on rollers carried on two parallel horizontal shafts which run in roller bearings, and which are geared together by a sprocket chain. One shaft only—Y—is, of course, seen in the diagram, as the other is immediately behind it. On the shaft Y is a pair of pulleys—fast and loose—for a belt drive. The barrels and screens are caused to revolve by reason of the friction between their rollers and the rollers on the driving shafts. It will be noticed that the rollers X and X1 are larger in diameter than the rollers X2 and X3, and the reason for the difference is that it is desirable to run the screens faster than the washing barrels. Usually Messrs. Hardy and Padmore arrange their screens to revolve half as fast again as the barrels. The faster speed of the screens renders them more efficient in action.



ARRANGEMENT OF GRAVEL WASHER AND SCREENER

Lifting the Kafue Bridge.

At Kafue (Northern Rhodesia) nearly 2000 miles from Cape Town, one of the biggest engineering feats ever attempted in Africa—South of the Line—the lifting of the Kafue Railway Bridge, which is 1398ft. long and weighs 910 tons, was satisfactorily carried out by the end of March. The bridge, which consists of thirteen spans, is one of the longest in Africa, and by the aid of twenty-eight hydraulic jacks it was gradually lifted from its twenty year-old foundation in order to rid it from the annual threat of flooding from the waters of the Kafue. The traffic was not stopped during operations. Trains were allowed over the bridge when all was made secure after each successive lift. The total height to which the bridge was raised was 5ft., and each lift was of 10in. When a lift was to be made jacks were placed in position under saddling girders, which joined the spans together, making the thirteen different sections, and each jack was worked by two natives under the order of a white man. When all was ready two whistles were given, and gradually but surely the fabric lifted. As the bridge rose huge wooden wedges were inserted, and under steady pressure were pushed home so that the weight was automatically taken from the jacks. When a 10in. lift was completed a concrete block was swung into place on each pier and cemented in position. If any trouble arose at any point during the lift a red flag was raised and work was stopped immediately by one whistle. It was estimated that the work of raising the bridge would require no less than 1000 concrete blocks, 1800 bags of cement, hundreds of feet of timber, and will have cost approximately £7000. While the lifting of the bridge was in operation, a gang was at work raising the land track at each end the necessary 10in., and the exactitude of the operation can be gauged from the fact that when a lift was completed the two sets of rails were absolutely flush. Every pier was inspected after the first train had crawled over the bridge, but, with the exception of a few face cracks in the newly inserted concrete blocks, nothing serious took place. If the cracks in the blocks looked more than mere superficial injury, the blocks were taken out and replaced.

It is doubtful if any attempt had previously been made to lift, as one piece, a bridge 1398ft. long, consisting of thirteen spans; certainly no such operation had previously been undertaken in South Africa.

The Kafue River intersects North Rhodesia roughly in an East to West direction, and the main line from Bulawayo to Broken Hill and the Congo is carried by the bridge. The lifting was so designed that there should be no interruption of the heavy coal and mineral traffic passing up and down this route, and in this connection, it may be said, everything worked out according to plan. As a preparation for the operations working stages were erected, or rather suspended, at each of the twelve piers. These stages consisted of a 12in. by 12in. timber from which longitudinal timbers were suspended by means of 5in. by ¼in. stirrup straps, to which were bolted 3in. by 3in. by ⅜in. angle irons, on which the longitudinal timber rested. The stage at the beginning of operations was 2ft. 4in. below the underside of the main girders, and as the work proceeded a working distance was maintained by the longitudinal timbers and decking being raised 10in. at a time, by means of the tackles used for setting the concrete blocks, until, when the last row of blocks was put in, the stage was 1ft. below the underside of the 12in. by 12in. cross timbers. This was effected by straps being holed every 10in. to take the bolts supporting the angle irons referred to above. The temporary steel work consisted of two R.S.J.'s 10in. by 8in., side by side, connected to the end cross girders of each span by means of stirrup bolts 1¼in. in diameter.

The jacks were only of 5in. diameter head, and hence it was necessary to fit a movable cap to distribute the load over both joists through the hardwood packing. On each pier two hydraulic jacks were utilised. The jacks were placed on the concrete blocks prepared for them, but after the first lift these blocks were replaced by native timber, packing being carried up continuous under both

cross girders, and followed with folding wedges, an extra safety packing being carried up with wedges under each cross girder independently. The same was done under the bearing plates of the main girders while lifting was in progress. When the 10in. lift had been attained, the temporary packing under the main girders was removed, the surface of the pier laid with 2 to 1 cement mortar, and the cement blocks brought in by means of tackles on the gantries and set into position. When the block was properly bedded, the wood packing was inserted under the bedding of the main girder, and the same operation performed on the main girder of the opposite span. When all four ends of the main girders on each pier, and on the two abutments, had been treated as explained, the bridge was lowered on to hard wood packings, and could take a live load, the jacks being free from all load. Thus, with the necessary raising of the permanent way at each end of the bridge, trains could, and did, pass over in safety after each lift. The whole of the concrete blocks required were cast on the spot, and it speaks well as to the quality of the material used when it is stated that after no single lift was it necessary to discard more than three of the blocks out of a total of fifty-two blocks in one tier.

During the work the men in charge continually had to fall back on their own ingenuity in devising various devices with which to cope with unexpected difficulties. In one particular case, for the purpose of placing overhead booms in position to carry the tackle for raising concrete blocks, a travelling crane was necessary. By the clamping of two ordinary trolleys together and fitting a wooden lever operated by a hand-controlled drum on which a cable was wound, the difficulty was surmounted. This strange looking erection is familiarly known as "Kabie of Kafue."

During the whole process of lifting the bridge no mishap of any description took place, nor did any hitch occur in carrying out the programme, except that on the day the fourth lift was to be done rain interfered with operations and the lift was carried out next day. The first lift of 10in. took actually 2¼ hours to accomplish; the third 1¼ hours, and the remainder under one hour. The scheme was designed and carried out under the direction of Mr. Rigley, the bridge engineer of the Beira, Mashonaland and Rhodesian Railway.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

General Conditions.

THERE has been little change to note during the week in the iron and steel trades of this district. A certain amount of small-scale business has been done, the fact that consumers are running on the barest possible margin of raw material being, no doubt, accountable for such activity as has characterised the market. Stocks generally are lower than they usually are at this time of the year. Consumers have not had sufficient opportunity to replenish them so far as some descriptions of steel are concerned, and as regards iron, users have no inducement to lay up reserves against future requirements while prices are receding from the abnormal levels to which they had risen. With the greatly increased output of steel last month, structural engineers are now able to get supplies on more advantageous terms. A good deal of heavy steel or constructional purposes is wanted, and it is believed that if further slight concessions were made in prices, more of this work would be placed. Engineers on 'Change in Birmingham to-day—Thursday—reported that there were more genuine inquiries about, both from home and export sources. Though generally optimism as to the future trend of trade is maintained, there are instances, especially in the South Staffordshire district, where manufacturers are becoming very sceptical, it being increasingly difficult to give profitable employment to productive resources. Arrears of work accumulated during the stoppage are being rapidly overtaken, and little new bulk business is forthcoming. The slight lowering of quotations appears to have availed nothing towards stimulating demand. It is anticipated that industry will feel some benefit from the cheapening of money by the lowering of the Bank rate. Any improvement in trade will be very welcome to Midland iron and steel masters, and, indeed, manufacturers generally.

Marking Imported Materials.

Considerable interest has this week been manifested by Midland industrialists in the application from the National Federation of Iron and Steel Manufacturers to the Standing Committee set up under the Merchandise Marks Act, 1926, asking that imported iron and steel should bear an indication of origin at the time of importation. The inquiry has been followed with close interest, for while, generally speaking, the majority of producers of iron and steel in this area favour the proposal, many engineers and merchants claim that no advantage would accrue, and consequently are against the compulsory measures. The goods which it was requested should be marked, included steel plates and sheets, rails, joists, angles, channels, sectional material of all descriptions, castings, forgings, rounds, squares, flats, hexagons, hoops, cold rolled strip, wrought iron bars, squares, plates and sheets. There has been of late considerable purchases of many of these classes of material by Midland users, and, although no real difference in the volume of business is anticipated, whether a marking order be made or not, yet the prevailing feeling seems to be that no real harm would be done and some good might possibly accrue by adopting the proposal. At any rate, it is agreed that consumers have a right to be correctly informed as to the origin of the material they purchase.

Railway Contract.

A welcome piece of business has this week come into the Black Country, the Great Western Railway Company having placed contracts for an electric traverser with Holt and Willetts, of Cradley Heath. Works in this area are none to well supplied with orders, and new business in such times as these gives considerable satisfaction.

Salop Sugar Beet Factory.

Active operations have now been commenced on the Salop Sugar Beet Factory at Allscott, Shropshire, and hopes are expressed that it will be completed in time for the 1927–28 crop. The contract, which has been placed with Perry and Co. (Bow), Ltd., provides for the completion of the factory by October 15th, 1927. Gratification is expressed that at last the scheme has taken definite form.

Steel.

There is a slight improvement in the steel situation. Some good business is stated to have been the subject of negotiation during the past week, and firm contracts are anticipated as a result. Local mills are now able to produce a wide range of steel, and the issue of the usual rolling lists affords considerable facilities to engineers requiring special lines of steel. Demand is not so insistent as it was a month ago, and works are speeding up deliveries with a view to obtaining new business. Requests for constructional steel are increasing in number, especially in connection with the erection of factory premises. It is urged that a further easing of steel prices is now necessary to induce an expansion of business. Steelmasters, however, do not see the wisdom of departing from recent levels. For angles and joists they want £7 15s., and for tees £1 more. Ship, bridge and tank plates are procurable at £8 7s. 6d., while boiler plates range from £11 to £11 10s. Small steel bars were offered to-day at £8 10s., and mild steel billets at £7. There is a poor demand for continental steel, and prices have fallen still lower. Sheet bars are offered at about £5 11s., and soft billets at £5 7s. upwards. Orders are small, consumers being fully persuaded that the depreciation will continue under pressure of competition.

Pig Iron.

The pressure for reduced quotations for raw iron is maintained, and furnacemen anxious to find outlets for their production are giving way. On 'Change in Birmingham to-day—Thursday—both Northamptonshire and Derbyshire brands could be bought on terms definitely more favourable than those which ruled a fortnight ago. Furnacemen are anxious to keep plants blowing if at all possible, and to this end they are willing to meet consumers. Some Derbyshire producers went as far as to accept £4 1s. for No. 3 foundry iron, but others declined to go below £4 2s. For forge they accepted £3 12s. 6d. Northamptonshire foundry was procurable at £3 18s., but many sellers wanted £3 19s. at furnaces. For forge the figure mentioned was £3 9s., or 1s. per ton below last week's minimum. Should blast-furnace coke prices give way, as it is now anticipated they will do, it is felt that the reduction would be passed on to the consumer of pig iron. Something like this is very much wanted to stimulate demand, which at the moment can only be described as flat. No contracts are being placed, and the tonnages required for immediate needs seem to be getting smaller and smaller.

Coke.

Though there has been, as yet, no definite break in prices of blast-furnace coke, the situation has become slightly easier, and a few contracts are stated to have been booked at slightly below the 22s. at ovens demanded by most ovenmen. Midland blast-furnacemen incline to the view that lower prices are in prospect. Should this become an actual fact the whole material market may be affected, for, as I have pointed out in recent letters, the present market stagnation is largely attributed to the false basis on which the iron and steel industries in particular have stood in consequence of the abnormally high cost of furnace fuel.

Finished Iron.

No reanimation of the Staffordshire finished iron trade can be reported, nor unfortunately is such a thing in sight. Staffordshire wrought iron makers are suffering severely as the result of keen internal and foreign competition. Impossible reductions in prices would have to be made to place Staffordshire makers in a position to compete successfully with their Belgian rivals. In the case of nut and bolt and fencing bars, local makers' prices are nearly double those of continental suppliers, and though Darlaston nut and bolt makers are busier, as the result of increased activity at the shipyards, they are for the most part drawing their supply of raw material from Belgian sources. Makers of Crown bars find business almost as bad though competition is not so keen or severe in their case. In this department it would appear demand is at fault, for most Staffordshire makers would be prepared to accept business at £11 per ton, which is also the Lancashire figure for this class of iron. Makers of marked bars remain moderately active, high-class engineering work calling for their products with regularity. The basis price of £14 10s. per ton is maintained. The call for wrought iron gas tube strip has fallen off somewhat, and values are easy at £12 10s. upwards.

Galvanised Sheets.

Galvanised sheet prices continue easy, 24-gauge corrugateds ranging from £15 to £15 5s. The resumption of work after the holiday, which was delayed at some of the mills owing to repairs having to be carried out, is now complete. Demand is fairly active, but considerably more work is needed to keep the mills fully employed.

Scrap.

The demand for steel scrap does not improve, and prices are easier, though quotably unchanged. Germany is reported to have bought considerable tonnages of this material at low prices.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Engineers in Conference.

The Conference of engineering employers and workmen, organised by the Manchester Engineering Council last week end, to discuss from both points of view the economic problems with which the engineering industries are faced, may be regarded as a highly successful venture, inasmuch as its main purpose was adequately served. Mr. W. L. Hichens, chairman of Cammell Laird and Co., Ltd., who discussed the problem of "Economic Production" from the employers' standpoint, said that they must face the fact that problems could not be solved by abuse of their opponents; far more could be done by proceeding on the lines of the Conference. Dealing with the present trade position, Mr. Hichens said he did not share the belief that our trade was improving. Foreign trade was slipping away to some extent because foreign countres were aiming at self dependence, but chiefly because our prices were too high. There were four essentials of economic production—punctuality, quality, quantity, and co-operation between capital and labour. Lateness of delivery was largely due to industrial disputes, and if they were to recover the goodwill of foreign customers they must do away with the need for a strike clause in their contracts. With that end in view, he suggested an industrial truce for a few years. Regarding the quality and quantity factors, Mr. Hichens pointed out that foreign countries had become more self contained, and our exports tended to rise in quality as a consequence; high-quality goods did not lend themselves to mass production on the American plan. Whilst he recognised the fact that output must be increased, there was the further fact that output required markets. The engineering industries suffered from the problem of redundant plant, and a solution for that problem had to be found. Co-operation between employers and employed was an extremely important matter, and those who expressed a belief in the mutual antagonism between capital and labour were behind the times. Economic production postulated the highest possible wage, besides low prices and a high output per head. The first practical step was for both sides to confer on co-operation to secure efficiency, an industrial truce, and the working out of detailed proposals by joint bodies.

What Labour Thinks.

The point of view of organised labour was expressed by Mr. W. M. Citrine, the general secretary of the Trade Unions' Congress, who said that labour had not been encouraged to believe that any real improvement of the standard of life was possible from within the capitalist system. A more recent tendency, however, was to examine the possibility of improving the system without abandoning the hope of a better, on the hypothesis that capital was not a fixed institution, and that if the trade unions came in with the employers a higher standard might be attainable. Mr. Citrine urged that for each industry, and for industries as a whole, there must be a regular national organisation capable of visualising industries separately and as a whole. On the question of co-operation between employers and employed, however, he feared that all practical possibility of that had been removed by the Trade Union Bill. While employers were really responsible for the proposals contained in that Bill, it was not consistent in them to ask for co-operation. Too often trade unions and employers met in an atmosphere of controversy over wages. If anything was to be done it must be by organisations representing respectively all employers and all unions. Consultation on detailed proposals should be by bodies inside each industry.

Non-ferrous Metals.

All sections of the market for non-ferrous metals during the past week suffered a serious relapse, and in each case unusually low levels were reached. Even for tin a fall of about £12 per ton in cash metal is not a light matter, but that is how prices stand at the time of writing compared with a week ago. Forward positions have been less severely affected, and a further reduction in the margin has occurred, only about £4 per ton now separating the two. The slump in values is attributed in some quarters as being largely due to outside political influences, but there is no doubt that buying for industrial consumption leaves much to be desired. The fall in the case of copper, spelter and lead has relatively not been much less serious, and for much the same reasons. Up to the close of the market last week-end, however, copper had been pretty steadily maintained, but a weak spell was experienced during the opening days of the present week, and buyers are operating cautiously. Both spelter and lead have lost about £1 compared with a week ago, offerings much in excess of consumption requirements having a marked influence on values.

Iron.

Pig iron producers are pointing with some justification to the scarcity and dearness of furnace coke as the reason for the comparatively high-priced iron; but, whilst it would be doing users an injustice to say that they do not recognise that fact, they are by no means anxious to stabilise pig iron prices at their present levels by buying with any degree of freedom. This policy has persisted steadily since the end of the coal stoppage, and it has been effective to the extent that, though current values are high, they are appreciably lower than they have been, and the continuance of that policy apparently has not lost its effect. Midland makers during the past few days, under the pressure of very poor buying, and under anxiety to prevent, as far as possible, the accumulation of stocks at the furnaces, have further reduced slightly their selling prices, and from 88s. 6d. to 89s. per ton, according to quantity, is the current range of quotations for Staffordshire and Derbyshire brands of No. 3 foundry iron, and including delivery Manchester or equal. A somewhat steadier tone is in evidence in the case of Middlesbrough brands, largely because the outputs from the furnaces

are going more freely into direct consumption at the steel works, and in this section of the market, values for delivery into this area are maintained at about 92s. 6d. per ton. Scottish makes are easy at a minimum of 102s., delivered Manchester, although it is not possible in this case to report any further concessions during the past week. Absence of strength is also apparent in the case of hematites, both East and West Coast varieties being quoted for delivery into the Lancashire district at about 94s. per ton. A poor demand for finished iron still obtains, with Lancashire Crown bars quoted at £11 and seconds at £10.

Steel.

Although sellers of steel on this market have expectations of good orders in the near future from local constructional engineering firms, the prospects of which are much brighter than they were a month or two ago, there is still marked reluctance among all buyers to buy in quantity or over an extended period at the range of prices that is being asked to-day. Actual new business is thus still light in the aggregate, although there seems to be a steady inflow of specifications against existing contracts. Many rolling mills are still in very active operation, but there is no doubt that, with new business so restricted, the position of most of them each week becomes less secure. Current values here of ship and tank plates range from £8 7s. 6d. to £8 12s. 6d., and of boiler plates from £11 7s. 6d. to £11 10s. Joists and sections, however, continue fairly steady at about £7 17s. 6d. per ton, as do also basic steel bars at from £8 12s. 6d. to £9 per ton, according to size. Re-rollers are still badly off for orders, and inquiry is very slow, small bars being easy at about £8 5s. per ton. In the absence of any notable improvement in the demand for continental steels, there has been a further reduction in values, billets now being quoted at £5 to £5 2s. 6d. per ton, delivered in the Lancashire district for cash against documents, sheet bars at £5 5s. to £5 7s. 6d., steel bars at £5 16s. to £5 18s., wire rods at £6 7s. 6d., joists and sections at £6 to £6 2s. 6d., ordinary plates at £7 to £7 2s. 6d., and Siemens' plates at £7 5s. to £7 7s. 6d. per ton. There has been a further sharp fall in galvanised sheets since last report, owing to the poor response from both domestic and foreign users, down to £14 12s. 6d. per ton, for the usual Indian specifications. This has been the basis of a moderate volume of business during the past week, and sellers are still apparently willing to accept the same figure.

The Institution of Locomotive Engineers.

By the invitation of Mr. S. F. Whalley, the general manager of the Vulcan Foundry, Ltd., Newton-le-Willows, between forty and fifty members and friends of the Institution of Locomotive Engineers (Manchester Centre), paid a visit to the Vulcan works on Friday, April 8th, 1927. On arrival at the works at 1.45 p.m. the party was welcomed by Mr. Whalley, and also by Mr. Lane, works manager, who, together with other members of the staff, personally conducted the visitors round the works. Much interest was displayed in the three-cylinder compound engines, which were being built for the London, Midland and Scottish Railway Company. At the conclusion of the visit the members were invited to tea by Mr. Whalley. Before leaving a hearty vote of thanks, proposed by Mr. G. N. Shawcross—vice-President of the Institution of Locomotive Engineers—and seconded by Mr. J. W. Smith—member of the Council—was accorded to Mr. Whalley and his staff for the very enjoyable visit and also for their kind hospitality. Mr. Whalley suitably responded.

Barrow-in-Furness.

Hematite.

There is no change in the position of the hematite pig iron market, and deliveries are still larger than orders booked. Makers are still busy on the accumulated orders, and deliveries on account of them will continue for a period yet, helped by small orders for immediate delivery placed by customers who are hesitating against placing orders for forward deliveries in the hopes of prices falling. This hoped-for reduction will depend, to a very large extent, upon a further fall in the price of coke, which still remains above the pre-dispute level. Production is maintained, all the furnaces being kept in, and stocks are kept down by the fact that the requirements of consumers are still heavy and also that the steel departments at Barrow and Workington are taking a fair proportion of metal. Wales, the Midlands and Scotland are taking a good tonnage, and the deliveries of special qualities are still well maintained. There is a good trade in ingot moulds, and it is likely to continue. In the iron ore mines there is plenty of activity, and there is a certain amount going out of the district. The foreign ore is being imported from the various ports, the heaviest proportion coming from Spain and Algeria. The steel trade is not bright, and fresh orders will soon be required if the works are to be kept employed continuously. This remark only applies to steel rails, sleepers and fish-plates. As far as the hoop and small section mills are concerned, they are assured of regular running in view of the contracts held and of those which are assured for the future.

Shipbuilding.

The work of completing the cruiser Cumberland is proceeding rapidly, and it will not be long before she is ready for her trials. The next launch will be in June, when the fast twin-screw passenger steamer for the Straits Settlements trade will leave the stocks.

SHEFFIELD.

(From our own Correspondent.)

On the Up Grade?

There is little change to report in the condition of the steel trade, but hopes of improvement are growing. The open-hearth furnaces are still busily employed, but are nearing the end of their arrears of work, and are not yet booking new business on the large scale which is desired. Although prices of pig iron are somewhat easier, hematite having dropped a shilling on the week, they have not fallen low enough to induce consumers to place large orders. At the same time, there is more confidence in the future. In support of their claim for higher wages, the engineers have drawn up a long list of important contracts which British firms have on hand for engineering and shipbuilding work. These orders will involve large demands for Sheffield material of various classes, on both the heavy and the light sides. Russia, which has been a very good customer for Sheffield files, tools, and saws, during the past two or three years, has not placed any substantial orders lately, but there are prospects of some coming forward in the early future.

The New Spanish Tariff.

The change in the regulations with regard to the importation of steel into Spain is not expected to affect Sheffield much. The duties on foreign steel have been raised to a very high level, but as they apply all round, Sheffield will not be subjected to any more competition from outside sources than in the past. The increase may, of course, stimulate home production, but, as there is only one important steel-making plant in Spain at present, any serious development would be a matter of time. It is satisfactory to learn that Spanish merchants and buyers prefer Sheffield goods and Sheffield business methods to those of any other country. There are in Sheffield six or seven firms which have for many years had a valuable connection with Spain in the supply of the cheaper grades of tool steel, spring steel, welding steel and files, and it is probable that they will be able to maintain their business.

The Lighter Trades.

An improvement is reported in several of the hand tool branches, and a fairly heavy sale is being experienced for heavy engineering and quarry tools, both at home and abroad. With regard to files, the position shows no immediate gain in strength, but prospects of an improved demand in the near future are considered good. The plate and cutlery branches are both depressed. Although colonial orders keep up fairly well, and there are some good contracts on hand for hotel and restaurant supplies, the trade done through the ordinary shopkeeping channels is on a very unsatisfactory scale. The total output is considerably below the average of last year, while prices and profits leave still more to be desired. Tenders for 35,000 clasp knives are being invited by the War Office.

Vickers' Report.

The annual report of Vickers Ltd., which was issued last week, has created a favourable impression. The period with which it deals is the first year since the reconstruction scheme was adopted. The balance of profit, after payment of debenture interest and provision for depreciation, is £562,284, as compared with £420,973 for the previous year. The directors propose to transfer £200,000 to reserve fund, and to carry forward a balance of £134,868. They do not recommend any dividend on the ordinary shares. They state that "having regard to the dislocation of trade due to the coal dispute, which was prolonged from the beginning of May to the end of November, the directors consider that under the circumstances the trading results obtained are satisfactory, and, although they regret that the payment of a dividend on the ordinary shares cannot be recommended, they believe that under normal conditions a dividend could have been paid." They add that during 1926 the business has been reorganised and considerable economies, both at head office and at the works, have been effected.

Colliery Developments.

Developments on a considerable scale, at the collieries of the Carlton Main Company, near Barnsley, are now nearing completion. They relate to three different departments of colliery work—the substitution of electricity for steam, the sinking of a new shaft, and the installation of a washery. The adoption of electricity in place of steam is an outcome of the success of early experiments, and a large central generating station has been built at Frickley, and equipped on the most modern lines, for the purpose of interconnecting the company's collieries for transmission. The station has a capacity of 22,500 kilowatts, which is adequate for the development, in accordance with up-to-date practice, of the whole of the coal leased by the company. A conversion of an almost all-round character has taken place during the past eighteen months, and the only steam plant remaining now consists of the large main winders and certain air compressors at the Grimethorpe and Frickley collieries. By means of a 22,000-volt line, a ring main connects the power station to the Grimethorpe, Ferrymoor and Frickley collieries, running to the Upton Colliery Company, and back to Frickley. At Grimethorpe a link is being made with the Houghton Main Colliery Company, and at Frickley with the Hickleton Main Colliery Company. Electric current is supplied at very cheap rates to the surrounding townships of South Elmsall, Moorthorpe, Brierley, Grimethorpe and Cudworth. The new shaft referred to is being sunk to the Parkgate seam at Grimethorpe. It is 21ft. diameter. The headgear is in position, and the electrical winders are approaching completion. The new washery, one of the finest in the country, is also at Grimethorpe, and has been brought into operation within the last few days. It is intended to serve not only Grimethorpe, but also the Brierley Colliery, and a line is now being laid from that colliery so that the tubs can be run direct from the pithead to the washery.

Corporation to Build Tramcars.

A considerable time ago the Sheffield Corporation built a number of tramcars in its own workshops, and now it is to carry out a further enterprise of the same kind. Its capital estimates for 1927–8 include £117,500 for fifty double-deck cars, twenty-five of which are to be built, at a cost of £58,750, under contract, and the other twenty-five, at a similar cost, in the Corporation workhops. It is estimated that during this year £55,763 will be spent on the new contract cars and £29,375 on the Corporation cars. It is expected that the new department will commence operations as soon as power has been obtained for the borrowing of the £117,500. At present no cars are being built for the Corporation under contract. An order for fifty double-deckers was recently completed by Cravens Railway Carriage and Wagon Company, Ltd., Darnall.

Electrical Contract for Holland.

The much-discussed action of the Southern Railway Company in giving a contract for electrical plant to Sweden, has been followed by the placing of an order in Holland by the Mansfield Corporation. The Electricity Committee of that body obtained tenders from both English and Dutch firms for a twelve months' supply of cables, and it recommended the acceptance of that of the Netherlands Cable Works, which was 20 per cent. lower than any English offer. The Corporation adopted the recommendation. The Committee anticipates spending £2000 on cable during the year, so that the saving to the rates will be £400.

Up-to-date Refuse Disposal.

New refuse disposal works, erected by the Chesterfield Corporation at Stonegravels at a cost of £7000, were officially opened last week. Heenan and Froude, Ltd., of Worcester, has supplied the plant, which is on the salvage principle, and introduces a new method which will reduce the cost of refuse disposal from £4170 to £3000 per annum. The apparatus will deal with 15,000 tons a year, and is electrically driven. The refuse is dumped into a hopper, at the bottom of which is an endless plate conveyor, that feeds the refuse into an elevator, and then into a screen, where the cinders and dust are separated. A magnetic separator picks up the tins, which pass into a mechanical baler, and the rags and paper, bottles and other saleable materials are extracted by hand picking. When all saleable materials have been taken out, the residue is charged direct into the incinerator fire. During the opening ceremony the interesting fact was mentioned that £30 had been received for the sale of tins in the first fortnight, and that an offer of £1000 had come to hand for tins for one year.

New Bridges at Rotherham.

The new Bow Bridge over the river Rother at Rotherham, which gives improved facilities for communication between that town and Sheffield, was opened on Monday by Sir Henry Maybury, Director-General of Roads, Ministry of Transport. The bridge, which replaces an old structure originally erected in 1723, has a width of 70ft. between parapets, with two footways, each 10ft. wide. It has cost, including the acquisition of property, upwards of £30,000, and the Ministry approved £27,415 as eligible for a 50 per cent. grant. The bridge was designed by Mr. Vincent Turner, the borough engineer, and the work carried out by George Longden and Sons, of Sheffield. The reconstruction of the Chantry Bridge is the next work of the same character which the Rotherham Corporation is anxious to take in hand, and Sir Henry Maybury announced that towards it the Ministry of Transport would grant £50,000.

NORTH OF ENGLAND.

(From our own Correspondent.)

Trade and the Bank Rate.

Though it is welcomed generally as a stimulative influence upon British trade, the effect of the fall in the Bank rate upon trade in the North of England has, so far, been imperceptible. In fact, the general trade position at the moment is somewhat discouraging, and new work is coming forward very slowly in all sections of industry. At the same time the undertone of confidence has not disappeared, and hope is expressed that another spurt in the placing of more business will be experienced in the very near future.

Cleveland Iron Trade.

The situation in the Cleveland pig iron trade leaves a good deal to be desired. A heavy tonnage is being turned out, but the business at present being done is on a disappointing scale. The inability of local pig iron producers to compete on anything like equal terms with continental makers has led to an almost complete suspension of the export trade, and the invasion of local markets by foreign iron. Nor is there any immediate prospect of a change in the situation. Possibly the recent fall in coke prices may in the near future be deemed sufficient to warrant a half-crown cut in pig iron prices, but a much bigger reduction is necessary to place Cleveland on a competitive level. In the meantime, makers adhere to the fixed prices, and are jogging along with such hand-to-mouth orders as they can pick up as a supplement to the contracts still running. There is no doubt, however, that they are becoming somewhat anxious as to the future. Orders are being executed at a much quicker rate than new is an early improvement, operations at the works may contracts are arranged, and it is feared that unless there have to be curtailed. No. 1 Cleveland foundry iron is 82s. 6d., No. 3 G.M.B. 80s., No. 4 foundry 79s., and No. 4 forge 78s. 6d. per ton.

Hematite Pig Iron.

East Coast hematite pig iron is slow of sale, notwithstanding its comparative cheapness. Makers are keen to put business through in order to keep furnaces blowing, though complaint is heard that quotations are unremunerative, and there are hints that a further fall in prices might necessitate serious consideration as to the advisability of keeping certain plant in operation. This week makers are asking 82s. 6d. for mixed numbers, and 83s. for No. 1, but these are full figures and can be shaded.

Ironmaking Materials.

Quietness again characterises the foreign ore trade, but big deliveries are coming to hand under running contracts. Best Rubio ore is firm at 22s. per ton, c.i.f. Tees. The fuel market has developed further weakness, and good Durham blast-furnace coke is now obtainable at 23s. per ton delivered at the works.

Manufactured Iron and Steel.

The steel works still maintain very big outputs and have substantial contracts still to execute. But there is also a lot of foreign steel coming into the district, and steel makers are by no means confident about the possibility of keeping up the present big-scale production. Certainly orders are now coming in slowly, and the chances of a drop in prices are being discussed. Whilst £8 7s. 6d. is the recognised Association price for steel ship plates and £7 17s. 6d. for angles and joists, it is understood that suitable business might be accepted at 5s. per ton below these figures.

The Coal Trade.

There is no particular sign of any activity setting up in the Northern coal trade, and the market is very slow. The recent cut in prices has brought a moderate amount of inquiry on the market, but foreign buyers are not yet content, and still press for further concessions. As is usual in the last week of a month, spot business has died down, and, while there are ample supplies of all classes of coals, there is no special pressure, and holders of definite lots have to make concessions to secure clearance. The outlook for next month is not very cheerful, but fitters say it will not be worse than April, as their contracts and other bookings already point to a full average demand, and, on every hand it is expected that the general demand will increase. Of course, what is wanted is a brisk increase, but that is problematical. The undertone of the market, while easy, shows that all operators are taking the view that demand is at its worst, and therefore steady improvement is fully anticipated throughout the coming months. Quoted prices are rather easy for prompt, but maintain a fairly steady tendency for forward. Best Northumberland steam coals are well booked for the next week or two, and a fair amount of tonnage has been stemmed. The collieries are just able to maintain prices in the neighbourhood of 14s. 6d. for best qualities and 14s. for secondaries. Best Durham steams are scarce for prompt at 19s. to 19s. 6d. Steam smalls are rather quiet, but fairly steady, best qualities being about 10s. 6d., secondary grades 10s., and special classes 11s. The gas coal trade position is not strong, but fitters decline to make any concessions and quote steadily at 17s. to 17s. 6d. for best kinds, and 15s. to 15s. 6d. for seconds. There is little new business offering for coke, but the demand is fully up to recent average, and any change is due to increased production. Gas coke for prompt is 21s. to 22s., and for over the year about 20s. Patent cokes are from 22s. to 25s. Beehive coke is in limited production and firm at 30s. to 37s. 6d.

Amalgamation of Coal Mines.

The first attempt at amalgamation of smaller units under the Mines Act of last year is now being made in Northumberland. It is proposed to combine in one concern the pits of the Cramlington Coal Company and the Seaton Delaval Coal Company. The former owns six pits and the latter company four, and they are situated within manageable distance of each other on the east side of the county. All these mines produce a similar class of coal.

SCOTLAND.

(From our own Correspondent.)

Markets Unchanged.

DURING the past week nothing has taken place calculated to improve the industrial aspect. Present activities are directed towards the overtaking of contracts held up during the strike period last year, and some manufacturers are fully employed. The present lack of fresh business is, however, beginning to cause uneasiness even to those busily occupied meantime. Most markets are comparatively inactive, and it would appear as though consumers are confident that ere long more advantageous prices will be available. At any rate, the present output of certain goods continues at a rate far beyond the inquiry, and those producers not concerned in the demand for deliveries against old contracts are having a very lean time. Hopes were, and still are, entertained that the many contracts for new shipbuilding work and constructional materials would mean a considerable amount of fresh business, but manufacturers report very slow developments, while the possibility of cheaper foreign material being utilised is always present. Meanwhile markets generally are most unsatisfactory and weaker in tendency.

Unemployment.

Unemployment is rife in the Broxburn district, where the mines and works belonging to Scottish Oils, Ltd., have been closed down since November last. Efforts have been made on behalf of the men to have work restarted, but without meeting any success. The company states that under the conditions ruling in the shale oil industry any reopening of the works and mines is impracticable.

Steel.

The volume of new business in the steel market is restricted. In some quarters, however, is is said that the lull is temporary, as many consumers have yet to purchase against contracts already in progress. Be that as it may, there is no doubt that new business is lacking, and producers not well placed with existing contracts are feeling the pinch. Those engaged on shipbuilding materials are not able to deliver quickly enough, and work at the shipyards is being retarded. Prices are unchanged, but makers can sell under Associated prices to the extent of 5s. per ton if necessary.

Steel Sheets.

It is said that there should be no shortage of business for sheets, and makers are confident that the present slackness is due to a concerted movement on the part of merchants to reduce prices. Makers state that quotations are already low enough to render protective measures necessary. Makers of best qualities are comparatively busy, but many are now indifferently employed.

Iron.

Bar iron and re-rolled steel have a poor market, and the easier prices named have brought little benefit. "Crown" quality bars are unchanged at £11 5s. per ton home delivery, but re-rolled steel bars can be done under the recent price of £8 5s. per ton home or export. There are thirty-four pig iron furnaces in blast in Scotland, and the output of foundry qualities is ample for all requirements, and hematite is only occasionally somewhat scarce. Imports of iron products during the past week amounted to 2200 tons, while exports totalled 6600 tons.

Coal.

Washed nuts still provide the feature in the coal market. These qualities are firm in all districts, with treble nuts outstanding. Round fuels are slow, and present prices are only maintained owing to reduced outputs. The absence of foreign business is especially disappointing, and the collieries in Fifeshire and the Lothians are the chief sufferers. Home demands also are slackening off, and idleness at the pits becomes more general. Collieries, however, are withstanding any further price reductions meanwhile. Aggregate shipments amounted to 236,397 tons, against 201,408 tons in the preceding week, and 205,428 tons in the same week last year.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Position.

THE conditions in the coal trade are now more settled following the holidays, although there is not a great deal of new business about for early loading and a quiet tone prevails. This is not to say that the conditions are easier so far as market values are concerned or that collieries are worse placed than they were immediately before the Easter vacation. As a matter of fact, the loading pressure is heavier than it has been for a very long time, and this may account to some extent for the apparent lull in operations, as most of the leading qualities are fully booked for the next week or so. Shipments last week were, as expected, reduced owing to the holidays, but the figures were, in all the circumstances, fairly satisfactory. Tonnage arrivals of late have been very good and on Monday of this week there were more steamers waiting to get into berth than has been the case for months past. The figure was thirty-four, which indicates that the collieries, or at least most of them, are very fully stemmed for prompt loading. At the same time there is the feeling that when the present pressure is disposed of a quieter period is more than likely. The general demand from abroad is far from brisk, though there are some interesting inquiries for delivery over a period. The Portuguese State Railways are in the market for 10,000 tons of half large and half small for shipment fairly promptly, while the Paris–Orleans and the French State railways have asked for prices for about 80,000 tons of smalls for delivery over three months. The French Marine is also reported to have asked for quotations for about 50,000 tons of Welsh coals for delivery at Cherbourg, Brest, Toulon and Bizerta over the next few months, and on May 3rd prices have to be submitted at Cairo for 100,000 tons of large coal for account of the Egyptian State Railways. It is understood that the Navagazione Generale Italiana has placed its order for five cargoes of about 7000 tons each for shipment to South America with the Maris Export and Trading Company.

Tin-plate Trade.

The Joint Standing Committee for the Tin-plate Trade met at Swansea on Monday, when the principal question for consideration had reference to the proposals submitted by the men's side for the revision of the basis of the sliding scale. That basis was originally fixed when wages in the industry were high, but for some time past it has been below zero, while *ex-gratia* bonuses have periodically been granted by the employers to meet the necessities of the lower-paid workmen. The agitation of the men for a revision has been proceeding for some time, but the difficulty has been to find a solution that would meet with the approval of both sides. The suggestion put forward on Monday by the representatives of the men was that the sliding scale should be based on the price of tin-plate bars, and that there should be a rise of 1d. for every 3d. advance in price, instead of the sliding scale being based on the price of steel bars. The men gave notice to terminate the existing scale, and it was agreed that the whole question should be referred to a joint sub-committee for consideration and report.

Current Business.

Generally speaking, there has not been any material change in the state of the coal market since I wrote a week ago. The weakest section of the market continues to be that for dry coals, while some of the collieries producing the inferior grades are in need of business; but in the case of Admiralty large and superior grades of Monmouthshires the tone is very steady, and buyers find it difficult if not impossible to break the prices quoted by colliery salesmen, who are for the most part very comfortably booked up for the next fortnight. Best Admiralty large coals fully maintain 23s. 6d. and best Monmouthshire large continue on the basis of 22s. to 22s.6d., while superior steam smalls are quoted at 14s. 6d. Patent fuel is a shade easier and coke is quiet, but pitwood is slightly steadier at 31s. to 32s. Anthracite coals maintain recent levels and shipments to Canada are proceeding actively, but from all accounts Welsh anthracite producers are experiencing increased competition from the United States. The Americans are cutting their prices very substantially in order to make a serious effort to recapture the Canadian market, which was wholly theirs until the big American strike a few years ago. The strike caused the Canadians to turn to South Wales, when it was found that Welsh producers could ship anthracite of a superior quality as cheaply as the Americans. Since then a big export business has been obtained for Welsh anthracite, but it is evident that shippers will have to watch the position very closely if they are to maintain their hold on this market.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. HUMPHREY M. MORGANS has been appointed President of the London branch of the Association of Mining Electrical Engineers for the year 1927–28.

ALFRED HERBERT, Ltd., of Coventry, requests us to announce that its "A.H." monogram, which it has used on its products for a number of years, is now registered as a trade mark.

AT a meeting of the Junior Institution of Engineers, held on the 21st inst., formal notification was given of the acceptance by Sir Murdoch Macdonald of the presidency of that Institution for the forthcoming session.

S. RUSSELL AND SONS, of Bath-lane, Leicester, ask us to announce that they have recently purchased the goodwill of the metal sawing machine department of Isaac Hill and Son, Ltd., St. George's Works, Derby, and have secured the services of Mr. D. M. J. Hill, late of that firm.

CONTRACTS.

J. STONE AND CO., Ltd., Deptford, London, S.E. 14, ask us to announce that the two propellers for H.M.S. Nelson were manufactured at their Charlton works from Stone's "Turbiston" bronze.

MIRRLEES, BICKERTON AND DAY, Ltd., of Stockport, have received an order for a six-cylinder 1715 B.H.P. "Mirrlees-Diesel" engine for the Reigate Corporation. This engine will, it is stated, be the largest oil engine supplied to any electricity undertaking in this country.

THE ELECTRIC FURNACE COMPANY, Ltd., of 17, Victoria-street, London, S.W. 1, has received orders for six Ajax-Wyatt brass melting furnaces, each of 600 lb. capacity, for a French firm, and also for a 100-kilowatt resistance furnace for annealing aluminium sheet in Scotland.

MIRRLEES, BICKERTON AND DAY, Ltd., of Mirrlees House, 7, Grosvenor-gardens, Westminster, S.W. 1, ask us to announce that at the new power station on the Clyde at Rothesay a five-cylinder "Mirrlees-Diesel" engine of 250 B.H.P., made by them at Stockport, has been installed. The new power station was officially opened on the 12th inst.

SIEMENS BROTHERS AND CO., Ltd., Woolwich, have just completed a new automatic telephone exchange at Stratford, New Zealand. The exchange has an initial equipment for 600 ordinary lines and 50 rural and party lines with an ultimate capacity for 900 and 100 respectively, and the equipment includes a two-position manual board and a one-position test desk.

THE EAST FERRY ROAD ENGINEERING WORKS COMPANY, Ltd., of Millwall, London, E. 14, has recently received the following orders:—Three 2-ton electric luffing cranes from Leach and Co., Ltd.; fourteen hydraulic capstans, four of 5 tons and ten of 1 ton capacity, from the Port of London Authority; fifteen hydraulic cranes; and for a complete hydraulic installation for the Victoria Jute Company, Ltd., Calcutta, comprising two hydraulic wharf cranes, one of 1 ton and one of 3 tons capacity, motor-driven hydraulic pressure pumps and an hydraulic pressure accumulator.

THE Great Western Railway officially announces that the following contracts have been placed:—(*a*) Supply, delivery and erection of new island platform covering at Newport—High-street—Station, Braithwaite and Co. (Engineers), Ltd., Broadway Buildings, S.W. 1; (*b*) construction of goods office and weighbridge office at Torre, Messrs. R. F. Yeo and Sons, Rock-road, Torquay; (*c*) supply of nine Lister auto-trucks, R. A. Lister and Co., Ltd., Dursley; (*d*) overhaul of ss. St. Helier, David Rollo and Sons, Ltd., Liverpool; (*e*) overhaul of ss. Sir Francis Drake, The Bickle Engineering Company, Plymouth; (*f*) overhaul of tug Swansea, Harris Bros., Ltd., Swansea; (*g*) supply of "Simplex" petrol engine for Didcot, The Motor Rail and Tramcar Company, Ltd., Simplex Works, Bedford; and (*h*) supply of electric traverser for Newton Abbot, Messrs. Holt and Willetts, Cradley Heath.

I.E.E. SUMMER MEETING.—Members of the Institution of Electrical Engineers are reminded that there is still time for them to send in their names if they wish to take part in the Institution's Summer Meeting at Newcastle-on-Tyne from the 14th to the 17th June. Intending participants are requested to notify the Secretary without delay.

JUNIOR INSTITUTION OF ENGINEERS.—The annual dinner of the Junior Institution of Engineers took place at the Monico Restaurant on Tuesday last, April 26th, and was attended by close upon one hundred members and guests. The chairman was Engineer Vice-Admiral Sir Robert B. Dixon, president of the Institution. The toast of "The Institution" was proposed by Brig.-General P. R. C. Groves, who spoke of the future of aeronautical engineering, and urged the great importance of developing our air services. Mr. R. L. Kirlew, the chairman of the Institution, responded. In a witty speech, Mr. H. T. Tizard proposed "The Engineering Industry," to which Sir Robert Dixon ably replied. The toast of "The Guests" was given by Mr. H. P. Wright, a vice-chairman of the Institution, and response was made by Sir Henry Fowler, president of the Institution of Mechanical Engineers, and Sir Murdoch Macdonald, who is the president-elect of the Junior Institution. Mr. W. M. Hurrel proposed the toast of "The Chairman" and Sir Robert Dixon replied in suitable terms, after which Sir Henry Fowler, also Captain Watts, of the United States Navy, expressed to the Institution the thanks of the guests. The evening was one which was thoroughly enjoyed, and a spice of surprise was added by the original and able way in which Mr. W. A. Tookey discharged the duty of honorary toastmaster.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
Native	18/6 to 21/–
(1) Spanish	18/6 to 21/–
(1) N. African	18/6 to 21/–
N.E. Coast—	
Native	18/– to 21/–
Foreign (c.i.f.)	22/–

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	4 5 0 to 4 7 6	
No. 1 Foundry	4 10 0	—
No. 3 Foundry	4 5 0	—
N.E. Coast—		
Hematite Mixed Nos.	4 2 6	4 2 6
No. 1	4 3 0	4 3 0
Cleveland—		
No. 1	4 2 6	4 2 6
Silicious Iron	4 2 6	4 2 6
No. 3 G.M.B.	4 0 0	4 0 0
No. 4 Foundry	3 19 0	3 19 0
No. 4 Forge	3 18 6	3 18 6
Mottled	3 17 6	3 17 6
White	3 17 6	3 17 6
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	4 0 0	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 18 0 to 3 19 0	
Foundry Forge	3 9 0	—
(3) Derbyshire—		
No. 3 Foundry	4 1 0 to 4 2 6	—
Forge	3 12 6	—
(3) Lincolnshire—		
No. 3 Foundry	4 1 6	—
No. 4 Forge	—	—
Basic	4 0 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 15 6 (a); 4 18 6 (b); 5 2 0 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	11 5 0	—
Best	—	—
N.E. Coast—		
Iron Rivets	12 15 0	—
Common Bars	11 15 0	—
Best Bars	12 5 0	—
Lancs.—		
Crown Bars	11 0 0	—
Second Quality Bars	10 0 0	—
Hoops	14 0 0	—
S. Yorks.—		
Crown Bars	11 0 0 to 11 5 0	
Best Bars	12 5 0	—
Hoops	14 0 0	—
Midlands—		
Crown Bars	11 5 0	—
Marked Bars (Staffs.)	14 10 0	—
Nut and Bolt Bars	10 5 0	—
Gas Tube Strip	12 10 0 to 12 15 0	

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	11 0 0	11 0 0
Ship Plates, ¾in. and up	8 7 6	£8 0 0 to 8 5 0
Sections	7 17 6	£7 10 0 to 7 15 0
Steel Sheets, under 3/10 in. to ¼in.	10 0 0 to 12 0 0	
Sheets (Gal. Cor. 24 B.G.)	—	£15 0 0 to 16 0 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 10 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 12 6	—
Soft Billets	7 12 6	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 10 0	—
Light Rails	8 15 0 to 9 0 0	
Billets	8 0 0 to 11 10 0	
Manchester—		
Bars (Round)	9 0 0	—
,, (Small Round)	8 5 0	—
Hoops (Baling)	11 0 0	11 0 0
,, (Soft Steel)	10 15 0	10 15 0
Plates	8 7 0	—
,, (Lancs. Boiler)	11 7 6	—
Sheffield—		
Siemens Acid Billets	11 0 0	—
Hard Basic	9 2 6	—
Intermediate Basic	8 12 6	—
Soft Basic	7 10 0	—
Hoops	12 0 0	—
Soft Wire Rods	9 5 0	—
Midlands—		
Small Rolled Bars	8 10 0 to 8 15 0	
Billets and Sheet Bars	7 0 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	15 0 0 to 15 5 0	
Angles	7 15 0 to 8 0 0	
Joists	7 15 0 to 8 0 0	
Tees	8 15 0 to 9 0 0	
Bridge and Tank Plates	8 7 6	—
Boiler Plates	11 0 0 to 11 10 0	

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	19/4½ to 19/7½
Block Tin (cash)	294 5 0
,, (three months)	290 5 0
Copper (cash)	54 16 3
,, (three months)	55 7 6
Spanish Lead (cash)	25 17 6
,, (three months)	26 7 6
Spelter (cash)	29 2 6
,, (three months)	29 6 3
Manchester—	
Copper, Best Selected Ingots	60 15 0
,, Electrolytic	61 15 0
,, Strong Sheets	86 0 0
,, Tubes (Basis Price) lb.	0 1 0½
Brass Tubes (Basis Price) lb.	0 0 11½
,, Condenser lb.	0 1 1½
Lead, English	27 7 6
,, Foreign	26 5 0
Spelter	29 12 6
Aluminium (per ton)	£107

FERRO ALLOYS.

(*All prices now nominal.*)

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/10½ per lb.	
Ferro Tungsten	1/5½ per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/6
,, ,, 6 p.c. to 8 p.c. ,,	£22 10 0	7/3
,, ,, 8 p.c. to 10 p.c. ,,	£22 7 6	6/6
,, ,, Specially Refined		
,, ,, Max. 2 p.c. carbon	£36 6	11/6
,, ,, ,, 1 p.c. ,,	£42 5 0	15/–
,, ,, ,, 0.70 p.c. carbon	£54 0 0	17/6
,, ,, ,, carbon free	1/5d. per lb.	
Metallic Chromium	3/3 per lb.	
Ferro Manganese (per ton)	£16 for home, £16 for export	
,, Silicon, 45 p.c. to 50 p.c.	£11 17 6	scale 5/– per unit
,, ,, 75 p.c.	£19 0 0	scale 6/– per unit
,, Vanadium	14/3 per lb.	
,, Molybdenum	5/– per lb.	
,, Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£170	
Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

(*Prices not stable.*)

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	14/6
,, ,, Ell	15/–
,, ,, Splint	15/6 to 16/9
,, ,, Trebles	14/3
,, ,, Doubles	13/6
,, ,, Singles	13/3 to 13/6
Ayrshire—	
(f.o.b. Ports)—Steam	14/–
,, ,, Jewel	16/6
,, ,, Trebles	14/–
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	13/– to 14/–
Screened Navigation	21/–
Trebles	14/6 to 15/–
Doubles	13/9
Singles	13/6
Lothians—	
(f.o.b. Leith)—Best Steam	14/– to 14/3
Secondary Steam	13/– to 13/3
Trebles	14/6
Doubles	13/6
Singles	13/3

ENGLAND.

	Inland.
(8) N.W. Coast—	
Steams	27/6
Household	42/6 to 58/6
Coke	29/– to 30/6
Northumberland—	
Best Steams	14/6 to 15/–
Second Steams	14/– to 14/3
Steam Smalls	10/6
Unscreened	13/6 to 14/–
Household	21/– to 27/–
Durham—	
Best Gas	17/– to 17/6
Second	15/6 to 16/–
Household	21/– to 27/–
Foundry Coke	24/6 to 26/6
Sheffield—	Inland.
Best Hand-picked Branch	32/– to 34/–
Best Selected House Coal	27/– to 29/–
Screened House Coal	23/– to 25/–
,, ,, Nuts	19/– to 21/–
Yorkshire Hards	18/– to 20/–
Derbyshire Hards	18/– to 20/–
Rough Slacks	10/6 to 11/6
Nutty Slacks	8/– to 9/–
Smalls	3/– to 5/6
Blast-furnace Coke (Inland)	22/– to 27/6 at ovens.*
,, ,, (Export)	f.o.b. 26/– to 27/–

(9) SOUTH WALES.

Cardiff—	
Steam Coals :	
Best Smokeless Large	23/– to 23,6
Second ,,	22/– to 22/6
Best Dry Large	21/– to 21/6
Ordinary Dry Large	20/– to 21/–
Best Black Vein Large	22/– to 22/6
Western Valley Large	20/6 to 21/6
Best Eastern Valley Large	20/– to 20/6
Ordinary ,, ,,	19/– to 20/–
Best Steam Smalls	14/3 to 14/9
Ordinary Smalls	13/– to 14/–
Washed Nuts	18/– to 22/–
No. 3 Rhondda Large	25/– to 26/–
,, ,, Smalls	16/6 to 17/–
No. 2 ,, Large	21/– to 21/6
,, ,, Through	18/– to 19/–
,, ,, Smalls	13/– to 14/–
Foundry Coke (export)	40/– to 45/–
Furnace Coke (export)	30/– to 32/6
Patent Fuel	25/9 to 26/6
Pitwood (ex ship)	31/– to 32/–
Swansea—	
Anthracite Coals :	
Best Big Vein Large	37/6 to 42/6
Seconds	31/– to 34/–
Red Vein	27/– to 29/6
Machine-made Cobbles	45/– to 50/–
Nuts	45/– to 47/6
Beans	37/6 to 40/–
Peas	21/– to 23/–
Breaker Duff	9/– to 9/6
Rubbly Culm	11/6 to 12/–
Steam Coals :	
Large	21/6 to 22/6
Seconds	19/6 to 21/6
Smalls	12/6 to 13/6
Cargo Through	16/6 to 17/6

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/– extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham. * Open market price. Special price for pig iron producers, 22/– per ton at ovens.

French Engineering Notes.

(From our Correspondent in Paris.)

The Rove Tunnel.

THE Rove Tunnel, which connects the Port of Marseilles with the Etang de Berre, was formally put into service during the week by the President of the Republic. Started in 1911, this vast enterprise has been continued uninterruptedly ever since, and the task of making Marseilles the terminus of the great waterway from Strasburg, and consequently from Central Europe, will be completed on the termination of the canal between Port de Bouc and Arles and the construction of the canal between Strasburg and the Rhone. The Rove Tunnel will do something more, since it will remove from Marseilles itself the cumbrous and dangerous cargoes and leave the new docks that now extend all the way to L'Estaque for normal traffic. It will also make the Etang de Berre the greatest inland port in Europe. It has an area of 370,000 acres and it is possible to construct around it close upon 50 miles of wharves. A considerable amount of dredging will, however, be necessary. The Etang de Berre is connected with the Mediterranean by the Caronte, which has been deepened and wharves have been constructed along practically its whole length. The Caronte Canal, with Port de Bouc at one end and Martigues at the other, has already become a great industrial centre. Huge chemical factories, oil refineries and other works, which would be dangerous near Marseilles, have been erected along the canal, and there is no doubt that in time the industrial activity will extend around the Etang de Berre. By the construction of the Rove Tunnel through the mountain range separating the Etang de Berre from Marseilles, that inland sea is now an extension of Marseilles, which has thus become one of the biggest ports in the world. It will depend upon two sources of traffic that seem to be capable of almost unlimited expansion—the inland waterway traffic from Central Europe and the traffic with North Africa, while it will always remain the "open door to the East." This enterprise, with the construction of the new docks as far as à L'Estaque, is one of the most remarkable yet undertaken, and is due entirely to the initiative of the Marseilles Chamber of Commerce, which has borne practically the entire cost.

The Languedoc Ship Canal.

At a time when it is very difficult to find the capital required to carry out some of the more urgent public works, it is obvious that many of them will have to be delayed for an indefinite period, and there appears to be small hope for some of the old schemes which are being revived in the belief that their execution is necessary to provide activity during the present period of industrial depression and to contribute ultimately to the permanent prosperity of the country. Amongst these schemes is the construction of the ship canal across France between the Mediterranean and the Atlantic. The idea originated nearly fifty years ago, when it was argued that the ship canal would relieve France of the supposed menace of Gibraltar. For many years a severe controversy raged over the feasibility of the scheme, for the reason, principally, that it would be difficult to keep the highest part of the canal at the Col de Naurouse supplied with water, but it was finally decided that there was really nothing to hinder its execution except the cost, the estimates of which varied between 950 million francs and 2000 million francs. The latter estimate provided for the construction of concrete walls the whole length of the canal. The smaller sum was obtainable, but in view of the financial risk involved, especially after the experience with the Panama Canal, the scheme could not be carried through Parliament. Since then much has been learned from Panama, as well as from the Kiel and other canals, and efforts are now being made to revive the Canal des Deux-Mers.

Midi Electrification.

Electric trains are being run experimentally between Bordeaux and Hendaye, on the Spanish frontier, and on the termination of the tests the electrified line will be officially put into operation, thus completing the second part of the Midi electrification scheme. The first part was the Dax-Toulouse line, with branches to the Pyrenees watering resorts. The length of the electrified system is now about 500 miles, or a quarter of the total mileage when the third part of the programme, providing for the electrification of the entire system, is completed. Work is now proceeding on the line between Porter-Saint-Simon, near Toulouse, and Ax-les-Thermes, with an extension to the Spanish frontier at Puygcerda. Of the hydro-electrical stations which will provide energy for the system three, totalling 106,000 horse-power, are already working and two others supplying 80,000 horse-power are nearing completion. It is proposed later on to construct dams across two other valleys, the Ariège and Têt, which will bring up the total energy available to 385,000 horse-power. Ordinary traffic will be greatly accelerated by the electric trains, and the locomotives for express trains will be of two types, one of 1000 horse-power and attaining a speed of 57 miles an hour, and the other of 1500 horse-power and capable of reaching the maximum regulation speed of 75 miles an hour.

Engineering Trades.

The only thing satisfactory about the engineering trades is the little more activity resulting from the distribution of considerable orders for locomotives and wagons and from the carrying through of the programme of naval construction. Some of the shipyards have also secured a few foreign orders. In a general way, however, there is very little being done for export, except in rolled iron and steel, which figure in the returns as manufactured goods, and on the whole there is nothing yet to justify the hopes of makers who had been expecting that the spring would bring about an improvement in trade. There is little being done at home, and it is becoming more and more difficult to secure foreign business, for the stabilisation of the franc is accompanied by increased production costs, and although there is probably still a margin in favour of French makers, the surplus production on the Continent is so great that it is increasingly difficult to obtain orders abroad.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

267,615. December 18th, 1925.—SLEEVE VALVES, H. R. Ricardo, 21, Suffolk-street, Pall Mall, London, S.W. 1.

This invention is particularly applicable to sleeve valves for internal combustion engines of the kind in which each cylinder is formed of aluminium, magnesium or an alloy thereof having a relatively high coefficient of expansion, while the sleeve valve is formed of a ferrous metal whose coefficient of expansion over the working range of temperature exceeds 16×10^{-6} per degree Cent., the piston working within the sleeve being formed either of a ferrous metal or wholly or mainly of a non-ferrous metal having a coefficient of expansion which approximates to that of the non-ferrous metal of which the cylinder is formed. Thus an example of a ferrous metal suitable for the construction of a sleeve according to the present invention is one containing 8 per cent. of nickel and 18 per cent. of chromium. The sleeve is constructed from a blank comprising a plain cylindrical metal tube A. The lower end of this tube is cut obliquely so that one side of the tube projects below the other as shown at B in Fig. 1.

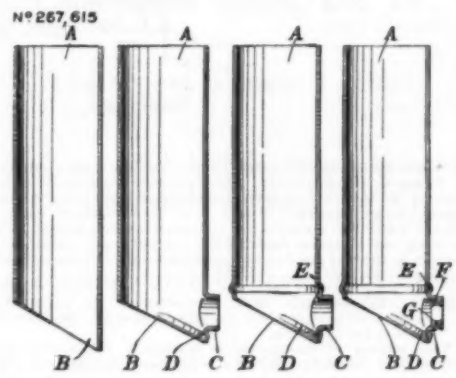


FIG. 1 FIG. 2 FIG. 3 FIG. 4

The first operation consists in pressing out laterally a part of this projecting part of the tube so as to form a hollow cylindrical boss C, as shown in Fig. 2, with or without one or more stiffening ribs or corrugations adjacent thereto. For example, a stiffening rib D such as that shown in Fig. 2 may be formed below the boss and substantially parallel to the oblique lower edge B of the sleeve in the same operation which forms the boss C. The second operation is to form, for example by rolling, a stiffening rib or corrugation E circumferentially around the sleeve about the boss, this rib being so disposed that it passes just above the lower edge of the shorter side of the sleeve and thus extends completely around the sleeve as shown in Fig. 3. The next operation is to secure within the boss a member F forming or connected to one part of a spherical joint or other flexible connection through which the desired motion is to be imparted to the sleeve. This member F, which may be, for example, the outer member of a spherical joint, is conveniently secured within the boss by pressing or rolling a portion G of the boss into an external groove on this member as shown in Fig. 4.—*March 18th*, 1927.

TURBINE MACHINERY.

267,405. September 9th, 1926.—SHROUDING FOR STEAM TURBINE BLADES, C. Oliver, Waverley, Bilton, Rugby, and W. Nightingale, 33, Oliver-street, Rugby.

This invention relates to the attachment of turbine blades to their shrouding, which is effected by inserting the ends of the blades through apertures into a trough-shaped shrouding and securing the blades by filling this trough with metal, such as silver solder or brazing metal. To secure the blades in position

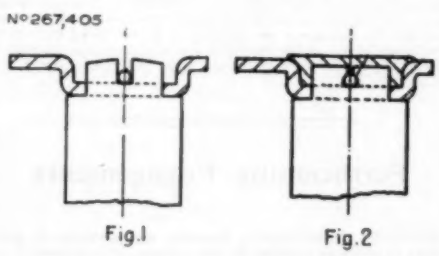


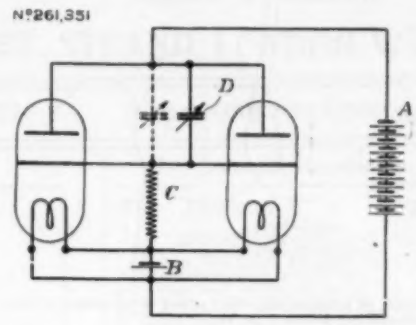
Fig.1 Fig.2

prior to the running in of the metal, a wire or rod may be made to engage in notches or holes in those parts of the blades which project into the trough. This can conveniently be done by forming these projecting parts with notches just wide enough to receive the wire which is pressed into them and then is retained in place by knocking over the edges of the notch by light blows. Fig. 1 shows the parts assembled, while Fig. 2 is of the completed work.—*March 17th*, 1927.

TELEGRAPHS AND TELEPHONES.

261,351. October 20th, 1926.—IMPROVEMENTS IN OR RELATING TO THE GENERATION OF ELECTRICAL OSCILLATIONS, Dr. Abraham Esau, of 1, Sophienstrasse, Jena, Germany.

The scheme of generating electrical oscillations described in this specification is mainly applicable to oscillations of short wave length and is intended mainly for the elimination of the disturbing action due to the so-called fading effect or to other causes. In the diagram two transmitting valves are shown with their anodes and grids and cathodes connected together, the circuit being completed with common batteries A and B and a high-resistance choking coil C. In order to generate a wave shorter than is possible with such an arrangement a variable capacity D is interposed between the two leads, connecting the anodes and the grids, thus forming two oscillating circuits. The



capacity must not be arranged as shown dotted, but asymmetrically as indicated at D. The asymmetry of the two oscillating circuits may, of course, be obtained in any other manner, as, for example, by using different valve constants.—*March 3rd*, 1927.

260,005. October 19th, 1926.—IMPROVEMENTS IN AND RELATING TO AERIALS FOR THE TRANSMISSION AND RECEPTION OF ELECTRO-MAGNETIC WAVES, Emil Geles, of No. 11, Strada Polizu, Bucarest, Roumania.

It is stated in various text-books, the inventor remarks, that the radiation of a closed circuit aerial is nil, but that is not strictly true. On the other hand, the inventor states that it has been shown and can be verified experimentally that the radiation

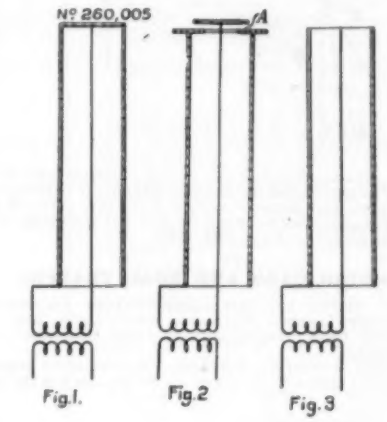


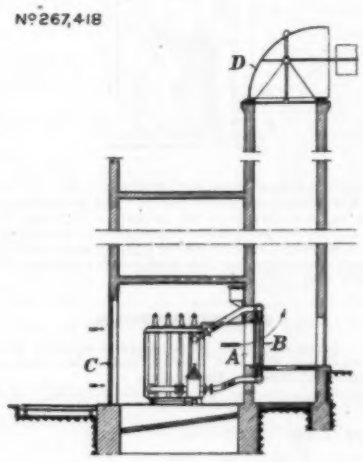
Fig.1. Fig.2 Fig.3

of an aerial increases with the surface exposed to the ether. The invention relates to a transmitting aerial constituted by a vertical tube enclosing a vertical wire, with which the tube forms a radiating closed circuit, without earth connection or counterpoise. In Fig. 1 the wire is connected directly with the tube as shown, whilst in Fig. 2 it is connected through a condenser A, whilst in Fig. 3 the wire is merely placed in the centre of the tube.—*March 24th*, 1927.

TRANSFORMERS AND CONVERTERS.

267,418. October 11th, 1926.—COOLING APPARATUS FOR ELECTRIC TRANSFORMERS, Otto Happel, of Konigsallee 45, Bochum, Germany.

A liquid cooling system is combined with an air flue A, so arranged that the heat from the transformer induces a flow of liquid through the cooling system by convection and also induces



a draught of air in the flue and draws cold air through the cooling system. The oil cooler B consists of tubes placed in the path of the air. In the opposite wall of the transformer chamber there is grid C for the inlet of air, which must sweep past the transformer before it reaches the cooler B. The flue has a cowl with a vane which causes it to rotate into the direction in which the wind is blowing.—*March 17th*, 1927.

PUMPING AND BLOWING MACHINERY.

267,300. March 2nd, 1926.—UNCHOKABLE PUMPS, Mather and Platt, Ltd., and R. Pennington, Manchester.

This invention is concerned with the form of the impeller

vanes of an unchokable centrifugal pump, and, in view of the drawing, needs no description, except that the arrow showing the

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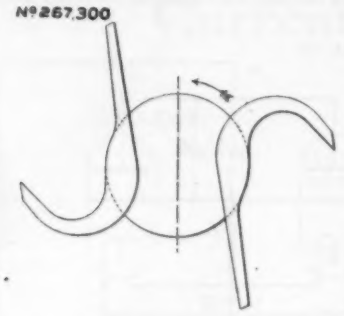

direction of rotation has been added from inference from the specification.—*March 17th*, 1927.

CRANES AND CONVEYORS.

267,825. October 13th, 1926.—Level-luffing Cranes, J. Jardine, Bickleigh, Brooklands-avenue, Uddingstone, Lanark.

In this crane, level luffing is effected by means of a rocking lever A which carries a sheave B round which the hoisting rope

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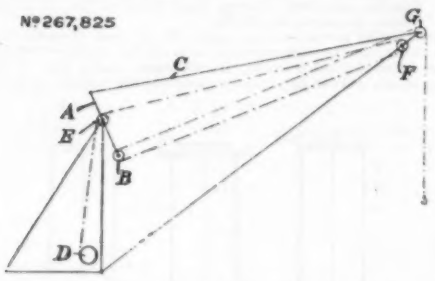

is rove. The upper end of this lever is connected with the jib head by means of a link C. It will be seen that the hoisting rope goes from the crab D over the sheave E and then to the jib head pulley F, back to the rocking lever sheave B and finally to the top of the jib at G.—*March 24th*, 1927.

MOTOR CARS AND ROAD TRAFFIC.

267,304. March 9th, 1926.—Improvements relating to Magneto-electric Machines, Joseph Lucas, Ltd., and Ernest Owen Turner, both of Great King-street, Birmingham.

The type of machine described is that in which separate windings are placed on the rotor, one for ignition and the other

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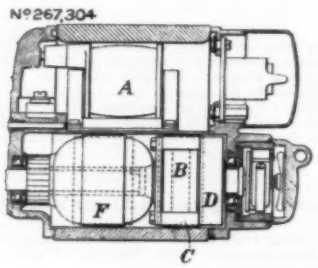

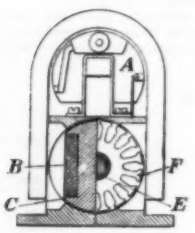

for lighting and general purposes. Within the arch of the magnet there is a stationary induction coil A. The generating winding B, which supplies current to the primary of this coil, is carried on a shuttle armature C, with an end piece D containing a condenser. For generating current for lighting and other purposes, an ordinary drum armature F is used, and is mounted on a sleeve E.—*March 17th*, 1927.

MISCELLANEOUS.

267,446. December 10th, 1926.—Coal-screening Plant, G. Fletcher and Co., Ltd., Derby, and F. M. Castleman, The Woodlands, Treeton, Rotherham.

The inventors propose to avoid the spreading of dust at

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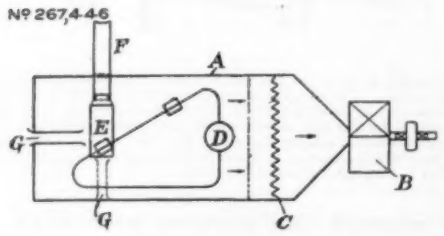

collieries and similar places by enclosing the whole of the pithead in an air-tight casing A, connected with an eduction fan B. There is a filter screen C at the inlet to the fan. The shaft itself is shown at D, a screen at E, and the picking belt at F. At the point where the belt emerges from the enclosure, a curtain is arranged to check the ingress of air; but definite air entrances are provided, at, for instance, G G, where dust may be expected to arise.—*March 17th*, 1927.

259,243. October 2nd, 1926.—Improvements in or relating to Alternating-current Rectifiers, *C. Lorenz Aktiengesellschaft, of Lorenzweg, Berlin-Tempelhof, Germany.*

The terminals of the alternating supply mains are connected to the primary winding of a transformer, the secondary winding of which supplies a synchronous motor A and two vibrating contacts B and C, which are oscillated in synchronism with the alternating supply by a cam disc D on the motor shaft. Arranged

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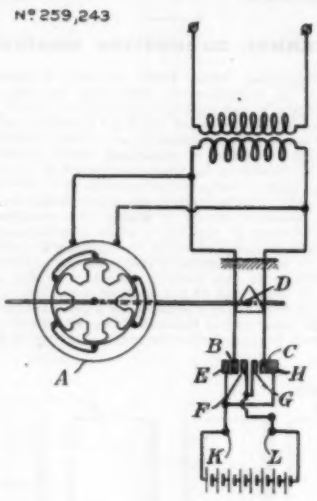
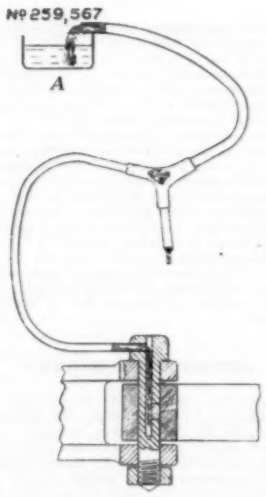


at both sides of each vibrating contact are stationary contacts E, F, and G, H respectively. The stationary contacts of similar polarity E, H and F, G are interconnected, and joined to the corresponding terminals K and L of the continuous current device, such, for example, as a battery to be charged. By utilising two vibrating contacts the necessity of a return connection to the mid point of the secondary winding is eliminated.—*March 17th*, 1927.

259,567. October 4th, 1926.—Lubrication by Capillary Action, Graissage Alcyl (Société Anonyme), 26, Avenue Carnot, Paris, France.

This scheme of lubrication is essentially the well-known syphon wick lubricator, but is so elaborated that one oil well,

No 259,567



such as that at A, may supply several points by means of branch lines. The capilliary oil ducts are formed, either of a natural material like rattan, or are built up of a tube filled with fibres. Details are given in the specification of the means adopted for connecting up the various branch lines of ducts.—*March 17th*, 1927.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

TO-DAY.

Diesel Engine Users Association.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Further Developments in Mechanical Injection Oil Engines," by Mr. Oswald Wans. 3 p.m.

Institute of Metals: Swansea Local Section.—Metallurgical Department of the University College, Singleton Park, Swansea. Annual general meeting. 7.15 p.m.

Institution of Electrical Engineers: Scottish Centre.—Technical College, Bell-street, Dundee. Paper, "Modern Electrical Wiring, particularly as Applied to Small Houses," by Mr. D. S. Munro. 7.30 p.m.

Institution of Engineering Inspection.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "The Stress-strain Diagram and its Application to the Testing of Rolling Stock Draw Gear," by Mr. L. H. Evans. 7.30 p.m.

Institution of Locomotive Engineers: Manchester Centre.—College of Technology, Sackville-street, Manchester. Paper, "Laminated Springs," by Mr. T. H. Sanders. 7 p.m.

Institution of Mechanical Engineers.—Storey's Gate, Westminster, London, S.W. 1. Paper, "The Failure of Some Steel Wires Under Repeated Torsional Stresses at Various Mean Stresses," by Professor F. C. Lea and Mr. F. Heywood. 6 p.m.

Institution of Mechanical Engineers: Yorkshire Branch.—Hotel Metropole, Leeds. Paper, "Internal Combustion Locomotives," by Lieutenant-Colonel E. Kitson Clark. 7.30 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Paper, "The Design and Balancing of Three-phase Low-tension Distribution Systems," by Mr. W. Fordham Cooper. 7.30 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, London, W. 1. Discourse, "Wireless Transmission and the Upper Atmosphere," by Dr. E. V. Appleton. 9 p.m.

MONDAY, MAY 2nd.

Society of Engineers.—Geological Society's Rooms, Burlington House, Piccadilly, London, W. 1. Paper, "The Internal Combustion Boiler (Brunler Flame)," by Mr. Oscar Brunler. 5.30 p.m.

TUESDAY, MAY 3rd.

Institution of Civil Engineers.—Great George-street, Westminster, London, S.W. 1. Thirty-third James Forrest Lecture, "Some Recent Services of Metallurgy to Engineering," by Professor H. C. H. Carpenter. 6 p.m.

WEDNESDAY, MAY 4th.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, London, W.C. 2. Wireless Section meeting. Papers, "The Holweck Demountable Type Valve," by Mr. C. F. Elwell; "Silica Valves in Wireless Telegraphy," by Messrs. H. Morris-Airey, G. Shearing and H. G. Hughes; "Cooled Anode Valves and Lives of Transmitting Valves," by Mr. W. J. Picken. 6 p.m.

Institution of Sanitary Engineers.—Caxton Hall, Westminster, London, S.W. 1. Paper, "House Refuse Collection and Disposal," by Mr. F. Wilkinson. 6 p.m.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. Dr. Mann Lecture, "English Railways," by Professor W. E. Dalby. 8 p.m.

THURSDAY, MAY 5th.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, London, W.C. 2. Annual general meeting. 6 p.m.

Institution of Mechanical Engineers: Yorkshire Branch. Visit to the Works and Ironstone Mines of Bolckow, Vaughan and Co., Ltd., at Middlesbrough. 11.45 a.m.

THURSDAY AND FRIDAY, MAY 5th and 6th.

Iron and Steel Institute.—Institution of Civil Engineers, Great George-street, London, S.W. 1. Annual meeting. For programme see page 428. 10 a.m. each day.

FRIDAY, MAY 6th.

Chemical Engineering Group.—Imperial College of Science and Technology, South Kensington, London, S.W. 7. Annual general meeting. Paper, "Chemical Fire Extinguishers," by Dr. W. R. Ormandy. 6 p.m.

Institution of Structural Engineers.—10, Upper Belgrave-street, London, S.W. 1. Joint meeting with the Société des Ingenieurs Civils de France. Paper, "Engineering Features of the Channel Tunnel," by Monsieur le Trocquer. 6 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Durham Bursar's paper, by Mr. W. A. Sallis. 7.30 p.m.

SATURDAY, MAY 7th.

Institute of British Foundrymen: Lancashire Branch.—College of Technology, Sackville-street, Manchester. Paper, "Some Aspects of Foundry Work," by Mr. E. Longden. 4 p.m.

Institution of Municipal and County Engineers.—Town Hall, Dover. South-Eastern District meeting. 11 a.m.

TUESDAY, MAY 10th.

Institution of Civil Engineers.—Great George-street, Westminster, London, S.W. 1. Annual general meeting 6 p.m.

WEDNESDAY, MAY 11th.

Electrical Association for Women.—Hotel Cecil, Strand, London, W.C. 2. Luncheon. 1 for 1.15 p.m.

Institute of Metals.—Institution of Mechanical Engineers, Storey's Gate, Westminster, London, S.W. 1. Seventeenth annual May Lecture, "The Growth of Crystals in Supersaturated Liquids," by Sir Henry A. Miers. 8 p.m.

THURSDAY, MAY 12th.

Institution of Structural Engineers.—10, Upper Belgrave-street, London, S.W. 1. Paper, "Some Problems in the Design of Steel Roof Truss Members," by Mr. A. G. Pugsley. 8 p.m.

MONDAY, MAY 16th.

Railway Club.—25, Tothill-street, London, S.W. 1. Paper, "Some Railway Byways," by Mr. C. N. Anderson. 7.30 p.m.

WEDNESDAY, MAY 18th.

Institution of Sanitary Engineers.—Visit to the works of A. and F. Pears, Ltd., at Isleworth. 2.30 p.m.

International Conference on Large Electric High-tension Systems.—The fourth session of the International Conference on Large Electric High-tension Systems will be held in Paris from June 23rd to July 2nd next. The Conference, the preceding sessions of which took place in 1921, 1923 and 1925, is divided into three sections, i.e., power production, construction of lines and working of systems, and thus offers to all its members an opportunity to acquire detailed information on matters of professional interest and to benefit by each other's experience in a much more effective manner than through the medium of books and periodical literature. It also enables them to meet personally. Twenty-eight countries are represented in the membership. In 1925 a total of 530 members attended the Conference, of whom 242 were manufacturers of electrical material, 251 power distributors, and 37 professors or consulting engineers. Two languages are used at the meetings of the Conference, viz., English and French, and all papers and discussions are translated from the one to the other. Full particulars will be supplied on application to the general secretary of the Conference, Mr. Tribot Laspière, 25, Boulevard Malesherbes, Paris.